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B.C. Rail RDC Prototype Evaluation

Prepared for
The Transportation Development Centre
Transport Canada

By
H.A. Simons (International) Ltd.
on behalf of British Columbia Railway

March, 1984

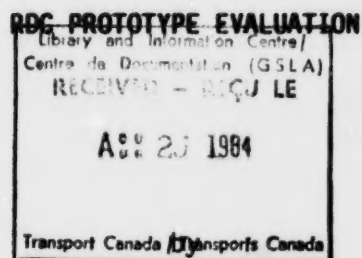
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TP 5345E

BC RAIL



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on behalf of

British Columbia Railway

March 1984

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre of Transport Canada.

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17. Abstract This report describes an investigation conducted from April 1983 to March 1984 to evaluate and assess the performance, reliability and public acceptance of the recently modernized self-propelled Rail Diesel Car (RDC) currently operating in regular passenger service out of Vancouver, British Columbia. Field tests were carried out on four trips between North Vancouver and Lillooet, B.C. spread over a seven month period commencing in August 1983. Vibration and noise tests were conducted on the first two trips with temperature control tests, passenger and crew surveys performed on all four trips. Both the modernized BC-33 and an unmodernized RDC were used for comparison purposes. Capital costs of the modernization program are reported by major element and a comparative evaluation is made of schedule adherence, reliability, operating and maintenance costs. The public acceptance of the modernized RDC was excellent and B.C. Rail was generally satisfied with the performance and reliability and is continuing its modernization program. Some changes including lowering of the passenger seat back, installation of a retractable centre armrest and simplification of the lavatory design are planned for future refurbishment. A less noisy auxiliary AC power unit and a more reliable air brake control system are being considered for refitting the remainder of the RDC fleet.			
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17. Résumé Ce rapport rend compte des travaux faits entre avril 1983 et mars 1984 eu vue d'évaluer le comportement et la fiabilité de l'autorail diesel modernisé (RDC) mis en service payant régulier par BC Rail, et aussi pour apprécier l'accueil réservé par le public. Les essais en service ont eu lieu à l'occasion de quatre voyages entre North Vancouver et Lillooet, en Colombie-Britannique, étalés sur sept mois commençant en août 1983. Les niveaux vibratoires et acoustiques ont été mesurés au cours des deux premiers voyages seulement, tandis que le contrôle des températures et les sondages auprès des passagers et du personnel de bord ont été faits lors des quatre voyages. Les essais ont visé tant l'autorail modernisé BC-33 que l'autorail RDC non modifié, ce dernier à titre de témoin. Le rapport fait la ventilation des coûts directs du programme de modernisation et établit un bilan comparatif sur les plans de la régularité, la fiabilité et les coûts d'exploitation et d'entretien. Encouragé par l'accueil fait par les voyageurs à l'autorail modernisé, et satisfait du comportement et de la fiabilité de ce train, BC Rail poursuit son programme de modernisation. Certains raffinements sont prévus, tels que l'abaissement du dossier du siège, l'installation d'un appui-bras central escamotable et un aménagement plus simple des toilettes. Enfin, cette compagnie envisage d'équiper le parc d'autorails d'une génératrice auxiliaire c.a. moins bruyante ainsi que d'un système de freinage pneumatique plus fiable.			
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SUMMARY

In 1981, the British Columbia Railway (BC Rail) commenced a major Rail Diesel Car (RDC) modernization program sponsored by the Province of British Columbia. The program was implemented to improve passenger comfort, to ensure in-service reliability, and to replace obsolete components.

This report describes the results of an investigation conducted from April 1983 to March 1984 to evaluate and assess the performance, reliability, and public acceptance of the recently modernized self-propelled RDC currently operating in regular passenger service out of Vancouver, British Columbia. Field tests were carried out on four trips between North Vancouver and Lillooet. These field tests were spread over a seven month period, commencing August 1983.

Vibration and noise evaluations were conducted during the first two trips. Temperature control tests and passenger and crew surveys were performed on all four trips. Both the modernized BC-33 and an unmodernized RDC were used for comparison purposes. Capital costs of the modernization program are reported by major element, and a comparative evaluation is made of schedule adherence, reliability, and operating and maintenance costs.

Public acceptance of the modernized RDC has been excellent. The BC Rail objective was to provide a modernized passenger car which would cater to tourism. Over ninety-five percent of the passengers indicated that they would like to travel again on the modernized RDC.

BC Rail have been generally satisfied with the performance and reliability of the modernized RDC and are continuing with their modernization program. It is estimated that the modification cost could be reduced by approximately 25% by eliminating or modifying some of the original modifications and by performing the work in the BC Rail Car Repair Shop in Squamish, British Columbia.

The interior refurbishment is generally very acceptable and attractive. The new coach seats are very comfortable and are preferred by the passengers, with the exception of the height of the seat-back which restricts visibility, and the non-retractable centre armrests. These will be redesigned on future modernization programs. The present seat configuration is considered to be the best arrangement possible, even though the view from some seats is partially blocked by the window support pillars.

The lavatory modernization is considered to be a partial success. Passengers have completely accepted the unisex lavatory concept, however, the maintenance costs of the lavatory operation have increased substantially. BC Rail are still looking for an effective method of performing these operations reliably. On future installations, BC Rail will give consideration to simplification of operation and improved maintenance access. In view of increasingly stringent railway dumping regulations, further research is required to design a toilet for railway passenger operations.

The modernized car heating and air conditioning systems function satisfactorily. The new design, utilizing an auxiliary AC power unit (APU) for the new AC powered air conditioning unit and galley operation, is considered practical. However, the two cycle engine chosen for this application is not acceptable due to the high noise level and high maintenance costs. Future modification programs should investigate the merits of using a 74 volt DC air conditioning system in conjunction with a smaller APU for the galley power versus the existing system utilized on BC-33.

The re-designed operator's cab and control console are considered optimum within the imposed space constraints. The design has had good acceptance by the engineers, with the expectation of the single-handle throttle and braking controller. The single controller has also proven to be a high maintenance item due to constant contamination of the circuitry controls. BC Rail are investigating a modified console which would have controls for throttle as well as an automatic brake and an independent brake. If this arrangement is adopted, the existing manual 'snow brake' would become redundant and could be eliminated.

The Cummins propulsion engines are excellent and reduce fuel consumption by approximately 16 percent. The twin-disc torque convertor and two-speed transmission are not reliable due to a higher than normal failure rate.

Overall, with respect to in-service reliability and schedule adherence, there is little difference between BC-33 and the other RDC's.

The galley modifications appear to be satisfactory for preparing pre-cooked meals. Future modifications will include the installation of a rear storage door and increased ceiling height.

SOMMAIRE

En 1981, British Columbia Railway (BC Rail) a lancé un important programme parrainé par la province de la Colombie-Britannique, visant la modernisation de ses autorails diesel, dans le but d'en accroître le confort, la fiabilité et l'efficacité.

Ce rapport rend compte des travaux faits entre avril 1983 et mars 1984 pour évaluer les performances et la fiabilité des autorails modernisés en service payant régulier, et aussi pour apprécier l'accueil que le public leur a réservé. Les essais en service ont eu lieu à l'occasion de quatre voyages entre North Vancouver et Lillooet, en Colombie-Britannique, etales sur une période de sept mois commençant en août 1983.

Les niveaux vibratoires et acoustiques ont été mesurés au cours des deux premiers voyages, tandis que le contrôle des températures et les sondages auprès des voyageurs et du personnel de bord ont été faits lors des quatre voyages. Les essais ont visé tant l'autorail modernisé BC-33 que l'autorail RDC non modifié, ce dernier à titre de témoin. Le rapport fait la ventilation des coûts directs du programme de modernisation et établit un bilan comparatif sur les plans de la régularité, la fiabilité et les coûts d'exploitation et d'entretien.

Les voyageurs ont très being accueilli ce service d'autorails modernisés, dont le but avoue est d'encourager le tourisme. Ce but semble avoir été atteint puisque, dans une proportion dépassant les 95 p. cent, les voyageurs ont dit qu'ils aimeraient recommencer cette expérience.

Satisfaite du comportement et de la fiabilité de l'autorail modernisé, la BC Rail poursuit son programme de modernisation dont elle espère pouvoir réduire le coût de quelque 25 p. cent en écartant certains de ses éléments ou en les réétudiant et aussi en effectuant elle-même une partie des travaux dans son atelier de Squamish.

Le réaménagement intérieur a été jugé très acceptable et attrayant. Les voyageurs ont trouvé les nouveaux sièges plus confortables que les anciens sauf que, estiment-ils, les dossiers sont trop hauts, ce qui bloque la vue, et que les appui-bras médians non relevables sont une gêne. Bonne note a été prise pour le prochain programme de modernisation. Il reste que la configuration retenue des sièges constitue la meilleure solution possible, bien que la vue depuis certains sièges soit en effet gênée par les montants des fenêtres.

Le réaménagement des toilettes n'a été qu'un succès partiel. Les voyageurs ont accepté l'idée de toilettes aménagées pour les deux sexes, mais, contre, le coût d'entretien a considérablement augmenté; aussi, la compagnie est encore à la recherche d'un moyen d'assurer cet entretien, convenablement et économiquement. Un des moyens envisagés est de simplifier les tâches par une plus grande accessibilité. Par ailleurs, il convient d'étudier une toilette plus appropriée à l'usage ferroviaire, compte tenu de la réglementation de plus en plus stricte concernant les méthodes de vidange.

Les systèmes de chauffage et de climatisation fonctionnent très bien. Le groupe électrogène auxiliaire, fournissant le courant alternatif pour la climatisation et la cuisine, est considéré comme une réussite. Mais le moteur à deux temps de ce groupe est trop bruyant et sone entretien, onéreux. La compagnie se propose d'étudier les avantages d'un système de climatisation 74 V courant continu associé à un groupe auxiliaire moins puissant pour alimenter la cuisine, par rapport au système actuel équipant les BC-33.

Le poste de conduite réaménagé est une autre réussite, vu l'exiguïté de l'endroit. Il a obtenu le suffrage des conducteurs, sauf en ce qui concerne la commande d'accélération et de freinage à poignée unique qui est, au surplus, d'entretien onéreux vu la constante contamination des circuits de commande. La compagnie étudie un pupitre comportant un accélérateur et un robinet de freinage automatique distincts ainsi qu'une commande de freinage indépendant. Si ce pupitre est adopté, la commande manuelle de "conditionnement" des surfaces de freinage pourra être abandonnée.

Le groupe de traction à moteurs Cummins donne satisfaction et fait réaliser des économies de 16 p. cent, environ. Le convertisseur de couple "Twin Disc" et la transmission à deux rapports ne sont pas très fiables, en raison des défaillances de l'embrayage, supérieures au taux normal.

Dans l'ensemble, la différence est minime entre le BC-33 et le RDC, pour ce qui est de la fiabilité en service et de la régularité.

La cuisine, réaménagée, permet de réchauffer des plats précuisinés. Il est prévu, d'y installer une porte d'entreposage arrière et surélever le pavillon.

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1.0 INTRODUCTION

Canadian railways have collectively owned and operated a fleet of approximately one hundred Budd Rail Diesel Cars (RDC's) for more than twenty-five years. The self-propelled, combination passenger and baggage/express freight cars were built in the 1950's. The cars have stainless steel bodies and are powered by two obsolete General Motors 6-110 diesel engines. They are currently being operated by BC Rail and VIA Rail in passenger service on secondary, low-density routes where the use of conventional passenger trains is not economically justified.

The problem of the gradual deterioration of the RDC was recognized in the mid 1970's and the Transportation Development Centre of Transport Canada (TDC) sponsored a feasibility study of its modernization performed by a consortium led by Canadian Pacific Consulting Services Ltd. A comprehensive 7-volume report was published in December 1976 providing guidelines for implementing an RDC interior/exterior/propulsion modernization program. VIA Rail Canada initiated a limited RDC improvement program involving replacement of the prime propulsion engines and interior refurbishing in 1979.

In 1982, BC Rail contracted with Versatile-Vickers Inc. to rebuild one of their RDC units. The primary objective was to provide a modernized passenger car which would cater to tourism. This included the replacement of obsolete components to ensure in-service reliability. The modernized RDC has been operating in regular BC Rail passenger service since October 27, 1982. The evaluation of the effectiveness of undertaking such a rebuilding program is addressed in this report.

The objective of this study is to evaluate and assess the performance, reliability and public acceptance of the recently modernized RDC currently operating in regular BC Rail passenger service.

The overall objective is to evaluate the effectiveness of rebuilding and modernizing the fleet of self-propelled RDC's operated in passenger service by BC Rail and VIA Rail.

Throughout this report, it should be realized that the modernized RDC, designated BC-33, is for all intents and purposes, a prototype. Also it was difficult to make a direct comparison between the cost and performance data of the unmodernized RDC's versus BC-33 due to on-going modifications and refinements to BC-33 during the study period.

2.0 MODERNIZATION PROGRAM

BC-33 was built in 1956 by the BUDD Company of Philadelphia, Pennsylvania. It is a modified RDC-3 configuration (a small kitchen replaces the Railway Post Office compartment). The car operates in regular passenger service between North Vancouver and Prince George, British Columbia. The BC Rail Passenger Train Schedule is exhibited in Appendix A. The remainder of the passenger fleet consists of 3 RDC-1's and 2 RDC-3's.

In 1981, BC Rail commenced a major RDC modernization program sponsored by the Province of British Columbia. This program was implemented to improve passenger comfort, to ensure in-service reliability, and to replace obsolete components.

Commencing June 29, 1981, BC-33 was removed from passenger service and was shipped to Montreal where it was stripped to the bare shell by Versatile-Vickers Inc. All interior and underframe equipment was replaced or rebuilt to an as-new condition. All coach seats were installed facing towards the 'A' end, and the operating controls at the 'B' end were removed restricting operation of BC-33 to the 'A' end only. The 'Revised General Specifications' are shown in Appendix B.

2.1 Exterior Body

All major dents, punctures and scratches on the exterior were repaired and new paint was applied in a stylized scheme with the British Columbia Railway name on the letterboard above the windows and diagonal white striping at each end of the car. All exterior doors and windows were repaired and resealed to provide a weather-tight fit. Lighting was improved by the installation of cornering and ditch lights and a higher powered headlight.

2.2 Interior Coach

The coach interior was stripped to the frame members, and was re-insulated and repanelled where required with new material to comply with current standards.

All windows were reglazed with safety glass, and window blinds were installed to assist interior temperature control, and enhance passenger comfort.

Seating capacity was reduced from 48 to 42 persons to provide increased leg room. Additional comfort was provided by installing cloth upholstered, reclining seats with built-in fold down food trays located in the seat backs. All seats face the forward direction and are track mounted for ease of changing the spacing. They also feature removable cushions for ease of cleaning and re-upholstering.

The baggage racks are cloth upholstered and feature built-in reading lights and music/intercom speakers. Fluorescent fixtures installed behind the racks provide indirect lighting. Several ceiling lights are also provided for aisle/night lighting. The ceiling is off-white to aid indirect lighting and the walls are finished in heavy wood-grain vinyl. The floor is covered in brown carpeting that extends up the wall to the window sill.

Figure 1, on Page 5, shows an artist's rendering of the modernized interior. The seat on the right side faces the rear of the car to depict the fold-down trays.

The modifications that were made to the galley and the operator's cab are described in Sections 4.4 and 4.5 respectively.

2.3 Lavatory

The lavatory at the 'A' end was eliminated in favour of a unisex lavatory at the 'B' end which was enlarged by 50% and was completely rebuilt with a retention type toilet. The interior finish consists of moulded plastic panelling with large mirrors. Other features include a moulded plastic sink with hot/cold water through a mixing valve, fluorescent lighting, a shaver outlet and recessed appurtenances. The toilet logic circuitry controls the flushing, chemical addition, masceration, and dumping. Dumping is inhibited at car speeds below 25 mph or at stations. Figure 2 on Page 6 shows an artist's rendering of the modernized lavatory.

2.4 Baggage Area

The baggage area has been re-insulated and refloored to current standards. The lighting and general appearance have been improved by application of a lighter-coloured paint and the installation of fluorescent fixtures. The elimination of a large freezer increases floor area. The baggage compartment also contains electrical and communications lockers, and provides access to the operator's cab.

2.5 Heating and Air Conditioning

Car heating is provided by surplus heat from the propulsion engines' coolant pumped through radiant baseboards, and through overhead coils in the air conditioning duct. A new AC-powered air conditioning unit replaces the previous obsolete system and delivers cool air to the coach section through an overhead duct and diffuser. The galley and operator's cab are also air conditioned.

Controls for heating and air conditioning allow selection of an automatic mode that provides heating or cooling as required by thermostats, or manual mode for maximum cooling or heating in the event of control malfunction.

2.6 Propulsion System

The propulsion system consists of two underslung, six cylinder, 340 Hp turbo-charged Cummins diesel engines, each coupled to a twin-disc torque convertor and a two-speed transmission. Each propulsion unit drives the inboard axle of one truck through a geared axle drive unit. The trucks, including the gear unit and disc brakes, have been rebuilt.

The Cummins engine delivers 25% more horsepower and improved fuel economy over the previous obsolete engines. It is water cooled through new roof mounted radiators, and features an integral mechanically driven compressor for the car air system and air brakes. The engine is equipped with an air starting system.

The transmission features adjustable power shift and lock-up speeds, and automatic retarding (hydraulic dynamic braking) when the engine is in first throttle position and the transmission is in second gear.

2.7 Air Brake and Wheel Slide Systems

The air brakes have been replaced by the 'Type 26' automatic braking system similar in part, to the system used on the railway's mainline locomotives. Supplied by the New York Air Brake Company (NYAB), the braking system is controlled by a common propulsion and braking control handle instead of the previous separate control levers. A manual 'snowbrake' feature allows partial braking in the power mode for conditioning brake shoes and discs in adverse weather.

Wheel slip/slide is detected by a micro processor logic system that also controls wheel slide to provide more effective braking and limit wheel wear. Wheel slide is controlled by the release of air from the disc brake cylinders, and by the application of sand onto the rails ahead of the powered wheels. The micro processor unit also provides a wheel slip/slide indication to the operator, and inhibits lavatory toilet retention tank dumping at stations or below 25 mph.

2.8 Electrical and Communication Systems

The increased galley electrical load and the unavailability of a suitable DC powered air conditioning unit necessitated the installation of an AC power supply. The Auxiliary Power Unit (APU) consists of a Brown-Boveri 55 Kw, 3Ø, 480 V alternator with a solid-state exciter and regulator, driven by a 4 cylinder, water cooled Detroit Diesel engine operating at a constant speed. The APU is self-contained, requires air for starting, and is installed under the car, below the baggage compartment. The APU also supplies power for the coach, baggage, and lavatory lighting, the coach baggage rack reading lights, the hot water tanks, and the utility receptacles.

The existing DC electrical system has been upgraded and retained for systems essential for car operation. All DC control equipment has been replaced and the car totally rewired to present standards. The system consists of nominal 64 vdc, 80 ampere hour batteries and two battery charging generators, one driven by each propulsion engine.

The DC power is used for car operational controls, radiator cooling fans, exterior lighting, interior emergency lighting, lavatory toilet operation, operator's cab heating, and car heating/air conditioning control. Although the electrical system is considerably different, BC-33 may be operated with other RDC's in multiple units.

In addition to the radio and location, identification and control (LIC) display systems, the car is equipped with a public address/intercom/music system. The intercom allows crews to communicate between the cab, the galley and the intercom station at the rear of the coach section.

A cassette player provides pre-recorded music via the baggage rack speakers and the public address system allows train crews to broadcast announcements.

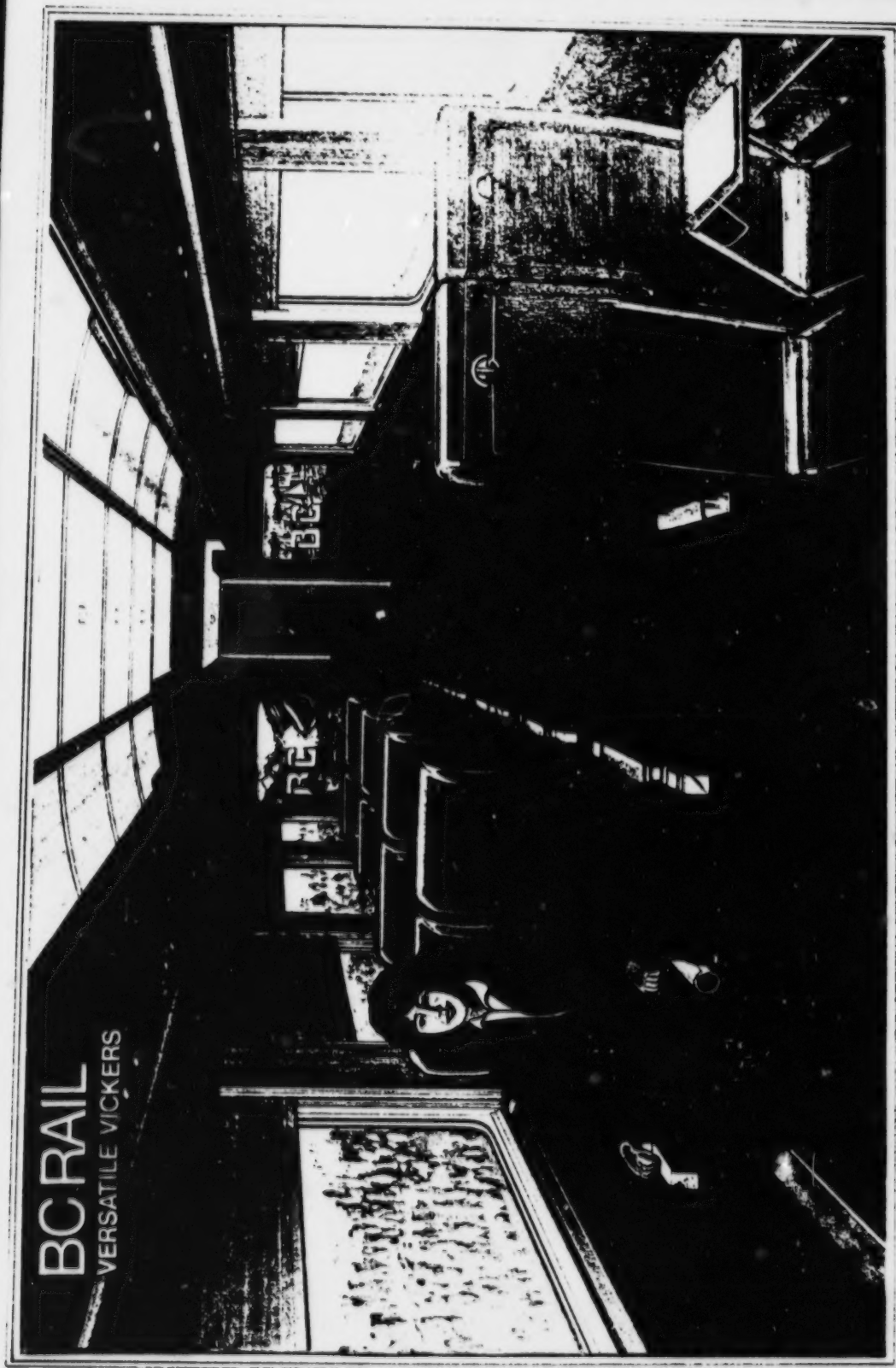


FIGURE 1

Crane Range Accurate Limited
P.O. Box 14
Sturminster Newton Dorset DT9 8BB
01202 626100



FIGURE 2

3.0 GENERAL METHODOLOGY

The methodology used to achieve the study objectives was divided into two separate parts.

One part consisted of the generation, collection and analysis of cost data related to the modernized RDC and an unmodified RDC. The other part consisted of four field tests on the modified RDC on a sampling basis of two round trips between North Vancouver and Lillooet, British Columbia in each of two different seasons.

The initial familiarization field trip was conducted on August 10, 1983 to conceptualize and discuss the format for operator and passenger surveys, and temperature, noise and vibration testing procedures.

The four field tests were conducted on the following dates:

- Field Test #1 - August 26, 1983
- Field Test #2 - October 26, 1983
- Field Test #3 - December 9, 1983
- Field Test #4 - February 22, 1984

Passenger and crew surveys and temperature control tests were conducted on all field tests. Vibration and noise tests were conducted on the first two tests only.

4.0 DISCUSSION AND RESULTS

4.1 Public Acceptance

In order to evaluate and assess the public acceptance of the recently modernized RDC currently operating in regular BC Rail passenger service, a passenger survey was administered on each of the four field test runs.

The sample questionnaire shown in Appendix C was developed to solicit passenger opinion concerning ride quality, seating, baggage, interior aesthetics, visibility and service. It was also designed to solicit pertinent market data for the BC Rail Passenger Department.

This section of the report serves to highlight certain aspects of the passenger survey which are directly related to passenger acceptance of the modernized RDC. Passenger responses for all four surveys have been tabulated and are summarized on the sample questionnaire. The total sample size consisted of 55 completed questionnaires.

Overall, the modernized RDC has been a tremendous success from a passenger viewpoint. The BC Rail objective was to provide a modernized passenger car which would cater to tourism. Over 95 percent of the passengers indicated that they would like to travel again on the modernized RDC.

It appears that a large portion of the passengers are tourists since 73% of the passengers were travelling on holiday or pleasure, and 71% indicated that they were travelling on BC Rail for the first time in the past twelve months. Approximately 47% of the passengers have previously ridden on the unmodified RDC's, but only 20% have ridden on BC-33; therefore, the survey was able to obtain valid passenger opinion to compare the modified RDC to the unmodified RDC's.

Most responses indicated that the traveller chose BC-33 in view of meal service (33%), reserved seating (26%) and more relaxed atmosphere (20%). Approximately 74% indicated that travelling in BC-33 was better than or much better than travelling by auto, and 91% indicated that travelling in BC-33 was better than or much better than travelling by bus. Only 36% thought that travelling in BC-33 was better than or much better than travelling by airplane. A total of 98% thought that the interior was very appealing (62%) or acceptable (36%).

With respect to using the public address system for announcements, opinion was divided; 55% in favour versus 45% not in favour. Of those in favour, some passengers requested only information concerning major scenic points of interest and major stations. The opinion concerning music was also divided with 56% not in favour of music. It is important to note that some of those who chose music qualified their answer by stating that it must be music of their own choice.

Part of the survey rated passenger response to features of the modified RDC. Most responses specified either acceptable or exceptionally good for seat tilt angles (96%), leg room (96%), overhead compartment (89%), and washroom (84%). Likewise, seat tray size (92%), seat tray operation (86%) and window visibility (85%) scored well. The blinds and seat lighting were used only sparingly.

In a few instances, seat tray size and operation were 'completely unacceptable.' These responses were received from passengers located in the front seats. These seats do not have fold-down trays, but utilize portable trays which insert into the seat armrest. Window visibility was another area of complaint. Eleven percent (11%) indicated that the visibility was completely unacceptable. In view of the fact that 49% of the responses indicated 'viewing the scenery' as a preferred activity, negative response concerning poor visibility deserves an explanation.

As part of the modification, new seats with high seatbacks were installed. Leg room was also increased which necessitated the repositioning of seats along the row of windows.

Unfortunately some seats are positioned opposite window support pillars which partially block the view. The view is further blocked fore and aft of the seat, and across the aisle by the high headrests of the other seats. Since the car was only partially full during the survey, passengers chose their seats on a 'first come, first serve' basis. With a full car of passengers, there will undoubtedly be more criticism about the height of the seat backs and the seat spacing.

These drawbacks must be weighed against the positive rider response concerning the modified RDC seat, the smoothness of the ride and the comfort of the ride.

Overall, most passengers indicated that they liked all aspects of the modernized car. Likewise, most passengers indicated that there were no unacceptable aspects, other than those stated above. Over 95% of the passengers indicated that they would be willing to travel again on the modernized RDC.

4.2 Temperature Control

In order to monitor temperature control, temperature levels were recorded on four field tests over two different seasons. These temperature tests were recorded on both the modified and unmodified cars. The main purpose of the test was to monitor the capability of the heating/air conditioning system of BC-33 compared to an unmodified car.

The first two tests monitored the capability of the air conditioning system to maintain a prescribed temperature setting, while the third and fourth tests monitored the capability of the heating system to maintain a prescribed temperature setting.

A new AC-powered air conditioning unit replaces the previous system and delivers cool air to the coach section through an overhead duct and diffuser. The galley and operator's cab are also air conditioned.

Controls for heating and air conditioning allow selection of an automatic mode that provides heating or cooling as required by thermostats, or manual modes for maximum cooling or heating in the event of control malfunction. The operator's cab temperature control is provided by two electric heaters totalling 5,500 watts, and by an overhead heating/air conditioning duct.

The heating system on the unmodernized cars consists of essentially the same system, except that it is not pressurized and it does not utilize expansion tanks.

On the first test, thermometers were placed in the operator's cab, the galley and the coach of BC-33. Since the unmodified car, BC-12, is a RDC-1, the thermometer was placed in the passenger coach area. Temperature levels were recorded every 30 minutes. The actual readings are shown in Appendix D, while the figures on Pages 10 to 13 show the ambient temperature versus the temperature of the coach of BC-33 and an unmodified car.

Legend

- * - BC-33
- A - Ambient
- o - Unmodified RDC

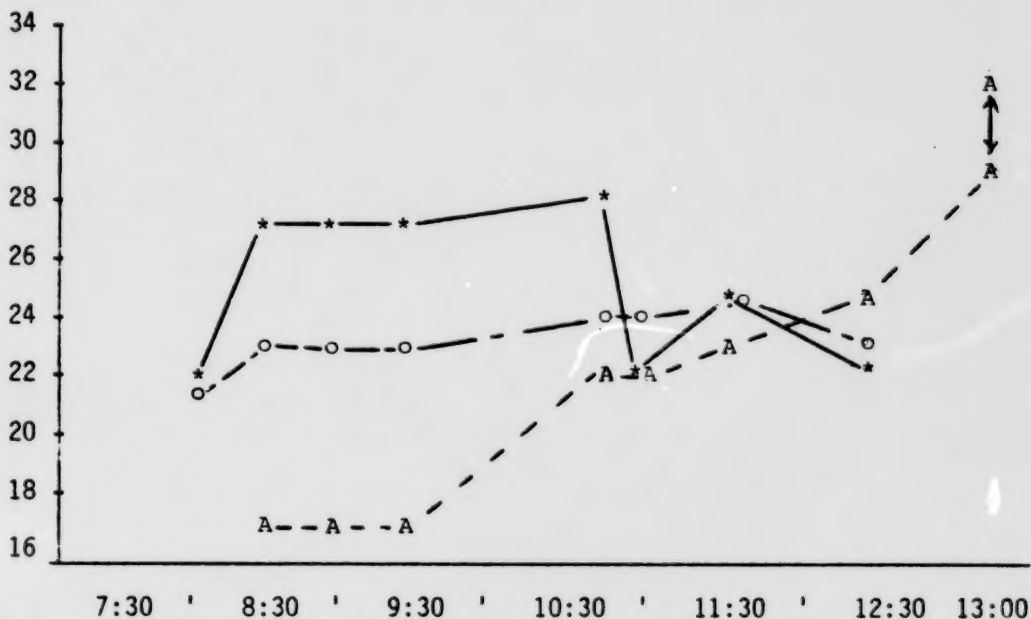


FIGURE 3 - Temperature °C versus Time (hours)

Test Run #1, August 26, 1983

During the first test run, as shown in Figure 3, the temperature of the unmodified car remained relatively constant, rising from 21.5°C to a high of 24.0°C, with a final reading of 23.0°C. A temporary rise in temperature may be a function of the coach temperature, the ambient temperature and the duration of time required to open the coach doors for embarking or disembarking passengers.

The temperature curve for BC-33 is not considered to be representative of the effectiveness of the air conditioning system. After 10:00 am, when the car temperature exceeded 27.0°C, the BC Rail staff were requested to check the thermostat setting. The control device was set on manual mode and was positioned midway between the cold and warm settings. After readjustment to a colder setting, the coach temperature decreased from a high of 28.0°C to a low of 22.0°C. It was then maintained at approximately the same temperature setting as the unmodified RDC.

During the test, temperature levels were recorded in the operator's cab. The test results are not indicative of the efficiency of the air conditioning system in the cab, since the Engineer maintained the cab windows and the cab door in an open position. This is common practice during the warmer months.

Temperature levels were also recorded in the galley. During operation of the galley heating appliances, the galley temperature was approximately 2.0°C to 2.5°C higher than in the coach. After lunch was served, Seat #41 near the curtained galley door, recorded a temperature level of 1.5°C higher than the mid coach seats.

Legend

- * - BC-33
- A - Ambient
- o - Unmodified RDC

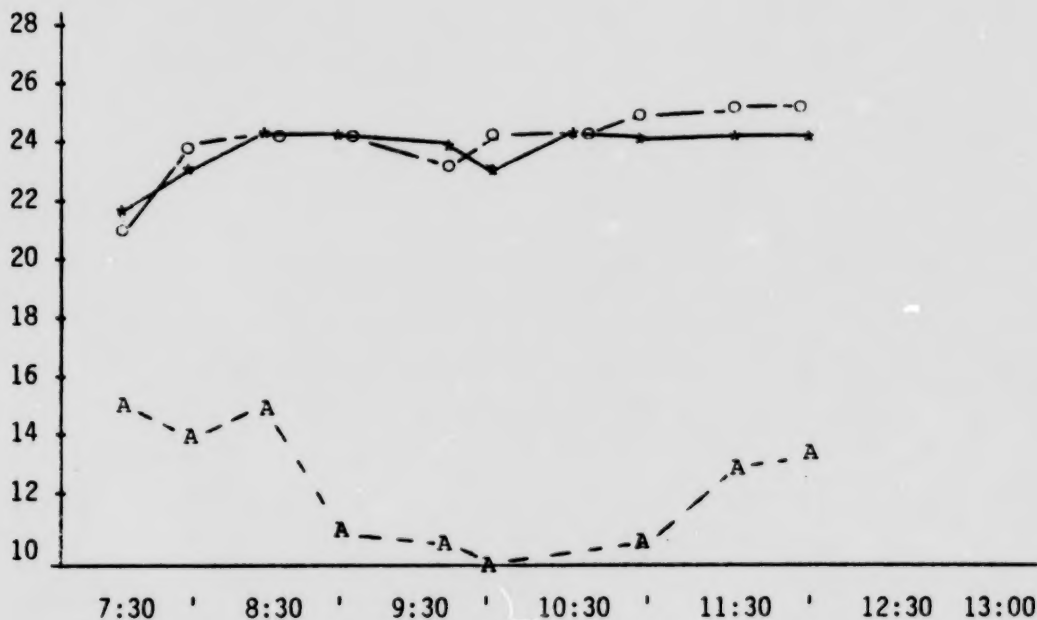


FIGURE 4 - Temperature °C versus Time (hours)

Test Run #2, October 20, 1983

As shown in Figure 4, the temperature levels of BC-33 versus the unmodified RDC are relatively constant. The thermostat of BC-33 was in the automatic mode and the coach temperature was not subject to the dramatic rises experienced in the first test run.

The temperature in the operator's cab was approximately the same as the coach. During this test the Engineer maintained the window and door in the closed position.

Legend

- * - BC-33
- A - Ambient
- o - Unmodified RDC

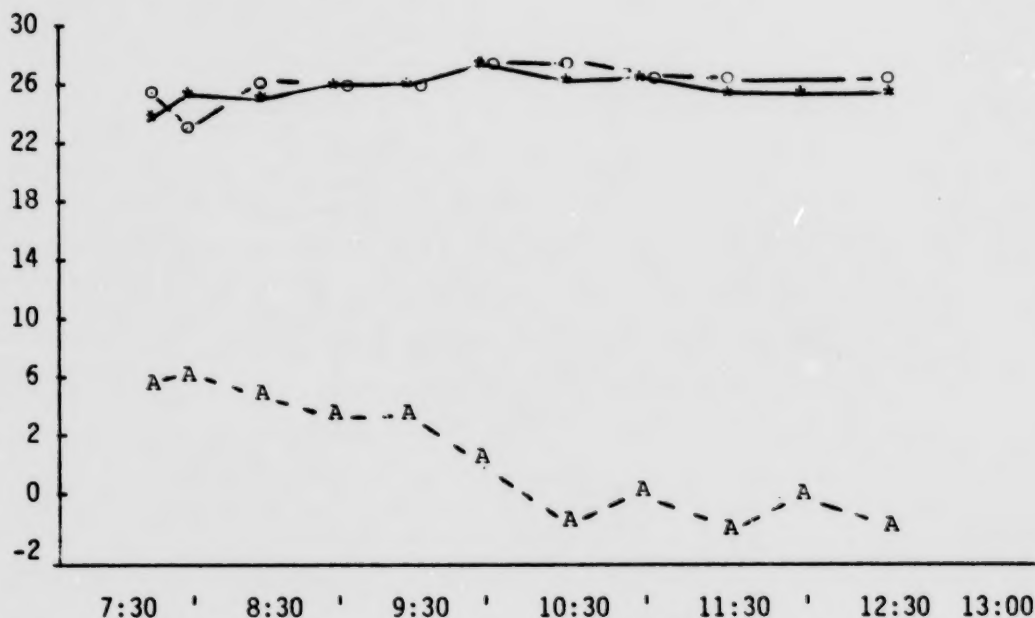


FIGURE 5 - Temperature °C versus Time (hours)

Test Run #3, December 9, 1983

For the third test run, both BC-33 and the unmodified RDC were conditioned for winter operation. Temperatures in both cars basically fluctuated between 24.0°C and 26.0°C. Placement of a thermometer behind Seat #1 at the 'B' end of BC-33 identified a severe draft around the door.

Initially the temperature was 16.0°C behind the seat, dropping to a low of 6.0°C half a meter from the door. BC Rail shop personnel were informed of the situation. Review of the passenger survey questionnaire identified a few complaints concerning a cold draft and diesel fumes. These complaints are no doubt attributed to the inadequate door seal.

Legend

* - BC-33
A - Ambient
o - Unmodified RDC

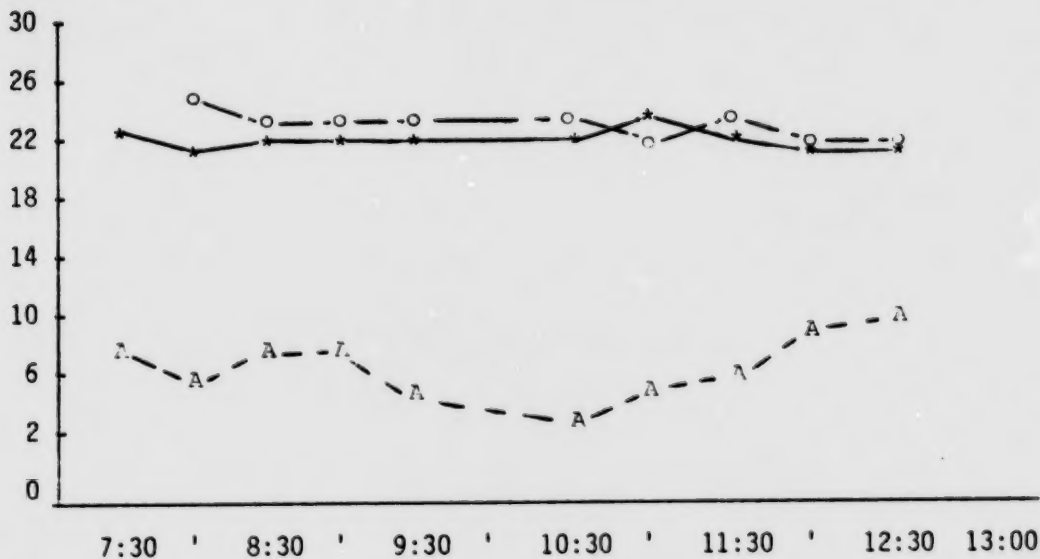


FIGURE 6 - Temperature °C versus Time (hours)

Test Run #4, February 22, 1984

The results of the fourth test are shown in Figure 6. The temperatures of BC-33 and the unmodified RDC remained relatively constant. Throughout the trip, the temperature in BC-33 remained approximately 2°C below the temperature of the unmodified RDC. Once again, the temperature test identified a lower temperature at the rear door. BC Rail personnel attribute the problem to poor alignment of the door and poor weather stripping. The situation has subsequently been rectified.

4.3 Ride Quality Evaluation

A ride quality evaluation was undertaken by testing sound, vibration and noise environments in passenger areas on BC-33 and on an unmodified RDC. The evaluation consisted of two independent tests. The objective of the tests was to measure the lateral acceleration parameter of vibration and to assess the ride quality in terms of "reduced comfort boundary" criteria and the rating method described in the International Standard ISO-2631-1978, "Guide to the Evaluation of Human Exposure to Whole-body Vibration" and Amendment 1 (1982).

All RDC's tested had identical suspension systems and propulsion engines. BC-33 weighed 131,400 lbs., while the unmodified RDC's weighed about 118,000 lbs.

4.3.1 Initial Overview Ride Quality Evaluation

During the first test, ride quality tests were conducted on Friday, August 26, 1983, on BC-33 and BC-12 during a morning north-bound run between North Vancouver and Lillooet, and on BC-31 during an afternoon south-bound run between Lillooet and North Vancouver.

The test results are detailed in Appendix E, 'Vibration and Noise Testing Overview.' The tables list the data obtained; vibration in inches per second squared peak-to-peak acceleration and audible noise in decibels weighting A. These measurement samples were taken at random. Exceptions are noted in the remarks column.

The following observations can be made from the findings of the overview run.

- 1) Sound level readings for the unmodified RDC revealed impulsive noise, whereas those for the modified RDC were relatively steady.
- 2) In preparation for the second run, consideration should be given for limited octave band analysis to yield better definition of acoustic factor in passenger ride quality.
- 3) Vibration transients occurred during travel on curved sections of track.
- 4) Vibration levels increased during periods of train acceleration.
- 5) The vibration acceleration values for the vertical direction generally exceeded that for the lateral direction.
- 6) It is to be noted that a time of day was recorded for each sample measurement. This was in accord with the test plan adopted at the commencement of the run which specified the use of BC Rail documentation to provide the desired speed data from correlation with time of day. Continuous braking and acceleration of the train, departures from schedule, and document deficiencies rendered this plan ineffective. In preparation for the second run, consideration should be given to a simple provision for speed information.

Ride Quality Assessment - Cursory and Tentative

The following points were noted:

- 1) For the preliminary overview test run, an assessment of passenger area noise, based on noise excesses relative to the criteria below, found few excesses and no significant difference between modified (BC-33) and unmodified RDC.

Selected objective noise tolerance criteria for passenger ride quality - Amtrak noise limit specification for passenger conversation activity 74 dB(A). (Reference: R. Higginbotham, "Ride Quality Evaluation," Transportation Research Record 894).

- 2) For straight track travel during the preliminary overview test run, an assessment of passenger area vibration, based on vibration excesses relative to the criteria below, found few excesses and no significant difference between modified (BC-33) and unmodified RDC. Vibration samples for curved track travel did exceed the discomfort criteria.

Selected objective vibration tolerance criteria for passenger ride quality; body discomfort - acceleration threshold (ignoring qualifying factors) 200 inches per second squared peak-to-peak acceleration. (Reference: G.R. Allen, "Vibration Requirements for Ride Quality," Transportation Research Record 894).

The preliminary overview run revealed:

- 1) Differences in the character (and passenger tolerance) of the noise in the two types of RDC's. Note: The unmodified RDC exhibited impulsive noise, rapidly changing in level or magnitude.
- 2) Vibration transients of significant magnitude during curved track travel and during periods of train accelerations.

The test results suggested that a second run should be planned to provide for acquisition of pertinent data and for the full evaluation and comparison of ride quality for the two types of RDC's.

4.3.2 Second Ride Quality Evaluation

Vibration testing took place on October 26, 1983 during a regular 5-hour trip from North Vancouver to Lillooet, a route distance of 157.5 miles. Curved track is prevalent along this route; train acceleration and braking are frequent, while speeds in excess of 45 mph are rare and of short duration.

BC-33 was the lead unit in a four unit consist. BC-12 was the second unit in the consist and was coupled to BC-33. Two accelerometers were oriented for lateral direction vibration and fastened by magnet to the support structures of passenger aisle seats, one at Seat #2 at the rear of BC-33, and one at Seat #86 at the forward of BC-12.

The instrumentation and data acquisition, and the vibration analysis are detailed in Appendix F.

Ride Quality Test Results

Figure 1 in Appendix F displays lateral acceleration time function graphs representative of the ride performance of the two rail diesel cars. Each graph exhibits 7 seconds of real time vibration. These graphs reveal RDC vibration levels for curved track significantly greater than those for tangential track on the Vancouver-Lillooet run.

RDC vibration crest factors were below 4 for tangential track and below 5 for curved track. The finding of crest factors within the Standard's upper limit of 6 establishes the suitability of the ISO 2631 rating procedures for ride quality assessment of the RDC vibration.

Figure 2 in Appendix F displays lateral acceleration spectra representative of RDC ride performance on tangential track, sampled in the vicinity of milepost 45 for a train speed of approximately 50 mph. These are narrow band (0.25 hz band width) rms acceleration spectra (0.25 to 100 hz range) evaluated over a period of one minute.

Figure 3 in Appendix F displays lateral acceleration spectra representative of RDC ride performance on curved track, sampled in the vicinity of milepost 52 for a train speed of approximately 30 mph. These are narrow band (0.25 hz band width) rms acceleration spectra (0.25 to 100 hz range) evaluated over a period of one minute.

Figure 4 in Appendix F displays a ride quality rating graph for the performance of the modified BC-33 RDC on tangential track; an 8 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

Figure 5 in Appendix F displays a ride quality rating graph for the performance of the unmodified BC-12 RDC on tangential track; an 8 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

Figure 6 in Appendix F displays a ride quality rating graph for the performance of the modified BC-33 RDC on curved track; a 2.5 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

Figure 7 in Appendix F displays a ride quality rating graph for the performance of the unmodified BC-12 RDC on curved track; a 4 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

4.4 Galley

The previous propane/electric kitchen has been replaced by a completely electric, unitized, stainless steel galley. The galley is equipped for preparation of conventional meals, or pre-cooked airline style meals.

Galley appliances include a freezer, a refrigerator, three coolers, two convection ovens capable of heating 48 pre-cooked entrees simultaneously, a microwave oven, a dual element cooking surface, an automatic ice maker, and a coffee (MOCCAMAT) dispenser. Storage cabinets, drawers and a food/beverage serving cart are also provided.

The catering staff were interviewed concerning galley convenience. Unfortunately, since BC Rail have not yet switched to the pre-cooked airline-style meals, the catering staff had to cope with cooking conventional meals on the two electric burners and the microwave oven. By removing the trays from the two vertical convection ovens, cooking capacity for conventional meals is increased.

The staff advised that the storage space is very good, except for the freezer compartment. Perhaps if pre-cooked meals were served instead of fresh vegetables, fish and meat, the freezer would be adequate.

Galley lighting and ventilation was considered to be good. The low ceiling (183 cm) caused by the overhead water tank, required the steward (191 cm) to stoop when using the galley.

Convenience of using the galley could be enhanced by relocating the coffee maker closer to the galley entrance. The present location, near the back of the galley, disrupts the preparation of meals when serving coffee.

The catering staff suggested that the installation of a small door at the back of the galley, in the baggage room, would reduce the time and effort required to load galley supplies. They also advised that they preferred not to use the serving trolley for the conventional meals. It is easy to deliver the trays two at a time immediately after placing the vegetables or buns beside the entree.

It appears that galley convenience could be greatly enhanced if airline-style meals were served or traditional convection ovens were installed.

4.5 Operator's Cab

The 'B' end vestibule has been retained with passenger egress equipment and has been cleared of all operator controls. At the 'A' end, the steps have been removed and the side doors sealed to provide a permanent operator's cab. The area has been insulated and has electric defroster equipped front windows and double glazed side windows.

Cab temperature control is provided by two electric heaters totalling 5,500 watts, and by an overhead heating/air conditioning duct. A wooden floor has been installed over the original steel floor to provide increased insulation, and the cab heater has been relocated to the electrical locker to provide additional space in the cab. Operator comfort is further enhanced with a wall mounted, adjustable locomotive style seat featuring a high back and folding armrests. An enlarged operator's window and the raised floor at the operating station provide maximum visibility and comfort within the existing cab dimensions.

The cab operating console features a "wrap-around" design finished in Kydex moulded panels. Figure 7, overleaf, shows the console. Recessed or built-in control equipment consists of a single handle throttle and braking controller, sanding switch, and horn and bell valves. Gauges and indicators essential for car operation are located on the console while other switches and controls are located within easy reach on the left hand collision post.

The engineers were interviewed to determine the level of acceptance of the cab modifications from an operator's viewpoint. All engineers were pleased with the increased visibility, the relocation of the controls and the addition of the high-back, adjustable locomotive-style seat. Likewise, the engineers found little fault with the unmodernized RDC unit.

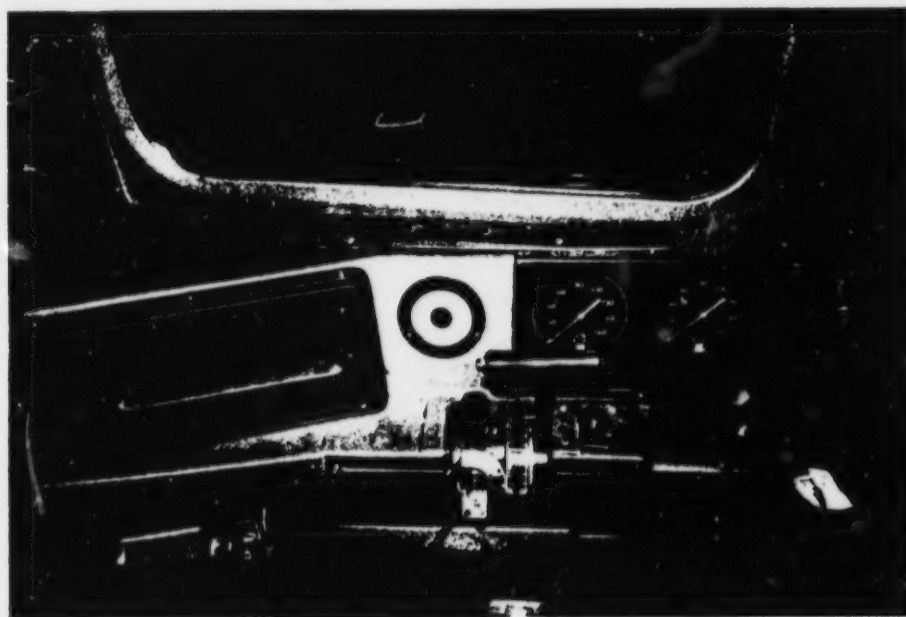
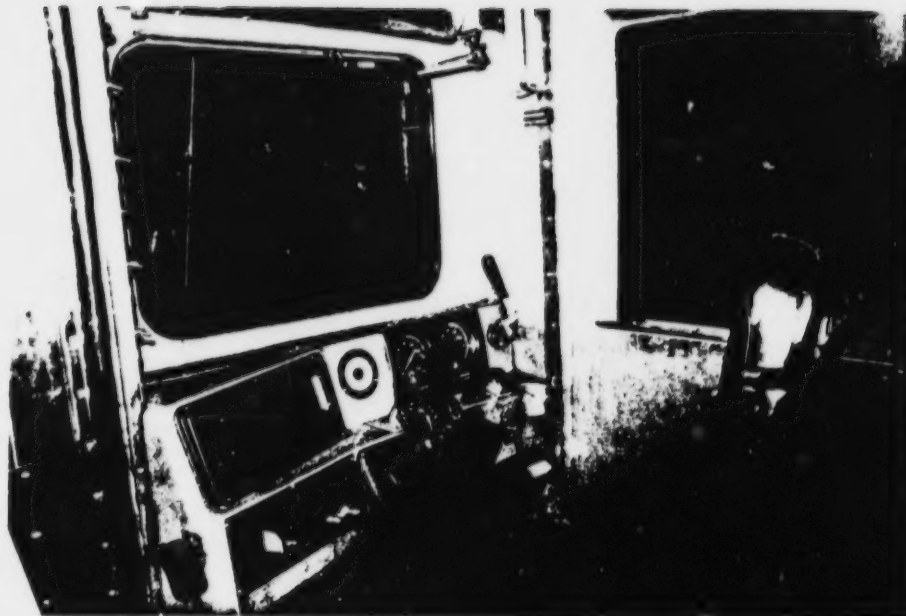


FIGURE 7

In fact, they preferred the two separate controls for the throttle and the brake. Therefore, there was a general dislike for the combination throttle and brake controller on BC-33.

In order to evaluate the ergonomics associated with the modernized cab, the engineers were observed while operating BC-33 and the unmodified RDC's. In the operator's cab, the prime requirement is to ensure adequate forward visibility to observe signals, the track ahead and around curves. In the unmodified RDC, the engineer had to sit in an unrelaxed position at the forward edge of the seat with his feet on the foot-stool. In BC-33, the larger window (10.6 cm wide x 7.9 cm high compared to 8.5 cm wide x 6.9 cm high) and the new seat and raised floor, enable the engineer to sit back and operate the car in a relaxed position.

On BC-33, the illumination and readability of the instruments is improved. The control panel has a textured non-glare finish and the bell and whistle controls have been relocated within normal reach.

4.6 Schedule Adherence and Reliability

In order to assess the schedule adherence and reliability of BC-33 versus the unmodified RDC's, the BC Rail Through Freight Train Reports were scrutinized for each day of passenger operations for 1981, 1982 and 1983.

All delays due to unscheduled maintenance of rolling stock, were noted and are recorded in Appendix G. The Transportation Department of BC Rail reviewed the Dispatch Reports to identify the RDC units in the consist, and to verify the reason for the delay. The purpose of the analysis was to determine the unit number and the cause for all delays longer than 10 minutes.

The data was analyzed for three separate periods of time:

- 1) During the 6 month period, **January 1981 to June 1981**, prior to the modernization of BC-33, the entire fleet of RDC's experienced 4 delays longer than 10 minutes in duration. None of the delays were attributed to the performance of BC-33. It should be noted that passenger service was temporarily curtailed from January 27, 1981 to March 20, 1981.
- 2) During the 16 month period, **July 1981 to October 1982**, when BC-33 was out of service for modifications, the remaining fleet of RDC's experienced 80 delays longer than 10 minutes in duration.
- 3) During the 14 month period, **November 1982 to December 1983**, with the modernized BC-33 in service, 77 delays longer than 10 minutes in duration were recorded. Of the delays, 27 (35%) were attributed to BC-33.

With respect to in-service reliability of BC-33 versus the unmodified RDC's, an analysis of the cause for delay was undertaken. When BC-33 was out of service for modifications, 38 (48%) of the 80 delays were attributed to the propulsion systems of the unmodified RDC's.

For the period, November 1982 to December 1983, 35 (45%) of the 77 delays were related to problems with the propulsion units. BC-33 had 12 propulsion related delays which accounted for 44% of it's delays or 34% of the delays attributed to the propulsion systems. The other units had 23 propulsion related delays which accounted for 46% of their delays. A review of the causes for other delays to BC-33 and to the other RDC units appeared to be fairly evenly distributed.

4.7 Cost Effectiveness

The purpose of this section is to evaluate the cost effectiveness of the RDC modernization program. This is achieved by first analyzing the costs of the major components which were modernized on BC-33, then comparing the operation and maintenance costs of the major service elements of BC-33 with an unmodified car.

Unfortunately, the analysis is clouded with a multitude of cost vagaries, subject to interpolation of labour and material costs. The following sub-sections describe the various cost components as best as possible.

4.7.1 Modernization Program

In the Spring of 1981, BC Rail decided to proceed with a program to modernize their fleet of 6 RDC's. The original concept was based upon developing a RDC prototype for an "order-of-magnitude" capital cost of \$600,000.00 to \$700,000.00. The prototype was expected to be completed in 8 to 10 months. Once the prototype was completed and evaluated, the remaining cars were to be scheduled in sets of two, at six week intervals.

On June 29, 1981, BC-33 was shipped to Versatile-Vickers Inc., Montreal, Quebec. Part way through the program, BC-33 was behind schedule and had cost overruns. BC Rail decided to renegotiate the contract to include the prototype only, not the original 6 cars.

On October 27, 1982, BC-33 was completed and shipped to North Vancouver, British Columbia. The modernization of the prototype took 16 months to complete and greatly exceeded the original cost estimate.

Table 1 overleaf details the labour and material costs for major components of the RDC prototype. These costs were estimated by BC Rail and Versatile-Vickers Inc. personnel in November 1981, based upon previous work experience and material price inquiries. Where possible, the costs associated with major components such as engines, have been verified with the actual invoices.

Since accurate detailed cost data is not available, Table 1 serves to show the approximate expenditures for the program. Specific details of the modernization program were discussed in Section 2.0, while Appendix B shows the "Revised General Specifications."

In view of the cost overruns, on December 1, 1983, BC Rail negotiated a final fixed price of \$1,400,000.00 for modernization of BC-33. Of this amount, Versatile-Vickers Inc. agreed that \$400,000.00 was the "upset price" on prototype engineering.

Under the original modernization plan, this amount would have been apportioned to the six-car fleet. For this reason, Versatile-Vickers Inc. agreed to modernize the remaining five RDC's for a fixed price of \$1,000,000.00 each.

Since BC-33 is a prototype car which contains a large amount of prototype engineering and specific "one-off" parts and material, future modification programs incorporating larger lots of cars should significantly lower the cost of modernizing each car.

TABLE 1
RDC PROGRAM COST SUMMARY

<u>Section</u>	<u>\$ Material</u>	<u>\$ Labour</u>	<u>\$ Total</u>
Car Body Exterior	2,200	48,400	50,600
Propulsion	151,600	18,800	170,400
U/F Equipment/Air Brakes	76,600	16,100	92,700
Operating Cab	19,900	16,100	36,000
Car Interior	158,200	64,600	222,800
Water/Toilet	22,000	8,100	30,100
Galley	54,900	10,800	65,700
Heating and Air Conditioning	37,000	10,800	47,800
Power Distribution and Control	16,300	54,000	70,300
P/A System	100	2,700	2,800
Baggage Compartment	2,800	10,800	13,600
Stripping of Components	-	67,300	67,300
Engineering	-	444,600	444,600
Stores	-	6,700	6,700
Tests	-	17,500	17,500
General Hardware	7,000	-	7,000
Miscellaneous	<u>10,000</u>	<u>-</u>	<u>10,000</u>
Sub-total	558,600	797,300	1,355,900
Tax and Mark-up (21%)	<u>117,300</u>	<u>-</u>	<u>117,300</u>
TOTAL	\$ 675,900	\$ 797,300	\$ 1,473,200

Source: BC Rail Mechanical Department

For production runs of 12 and 24 cars respectively, the unit cost per RDC modernized may be reduced to a cost in the order of \$853,000.00 and \$805,000.00. These figures are presented for illustrative purposes and are based in part on the experience of the original BC Rail Project Team and subsequent in-house modifications to the remaining fleet.

For the above estimates, "first-time" costs and prototype engineering have been eliminated. It is assumed that labour input could be reduced by 21% and 25%, based upon BC Rail's experience related to re-engining their remaining fleet of RDC's.

It is assumed that the price of material purchases could be reduced by an average of 15% and 20% respectively. During the original program, many suppliers were reluctant to quote on limited production items. Large orders may produce substantial price reductions on specific components.

4.7.2 Maintenance Costs

The maintenance cost data for BC-33 is shown in Appendix H and has been compared to the maintenance cost of BC-31, an unmodified RDC operating in similar service. For analysis of cost effectiveness, it would be beneficial to have the data segregated into major service elements to as great an extent as possible; however, the BC Rail labour and material costs are based upon purchase requisitions and time cards, and are charged to general categories for the repaired unit. Greater cost detail will not be available until BC Rail implement a computerized Work Order System.

The results of the analysis have been summarized into the following three categories:

(1) Period: July 1980 to June 1981

BC-33 (before modification or upgrading) versus BC-31.

<u>Costing Area</u>	<u>Average \$ per Month</u>	
	<u>BC-33</u>	<u>BC-31</u>
Labour	\$ 852	\$ 713
Material	414	234
Outside Service	30	50
Total	\$1,296	\$ 997

(2) Period: July 1981 to October 1982

BC-31 (while BC-33 out of service for modification).

<u>Costing Area</u>	<u>Average \$ per Month</u>	
	<u>BC-31</u>	
Labour	\$1,615	
Material	1,697	
Outside Service	297	
Total	\$3,609	

(3) Period: November 1982 to October 1983

BC-33 (after modification) versus BC-31.

<u>Costing Area</u>	<u>Average \$ per Month</u>	
	<u>BC-33</u>	<u>BC-31</u>
Labour	\$3,442	\$2,970
Material	1,906	989
Outside Service	576	50
Total	\$5,924	\$4,009

The period, July 1980 to June 1981, shows that monthly maintenance costs for BC-33 versus BC-31 were approximately the same. The period, July 1981 to October 1982, shows an increase of \$2,612.00 per month or a 262% increase for BC-31.

The period, November 1982 to October 1983, shows monthly maintenance costs were \$5,900.00 for BC-33 versus \$4,000.00 for BC-31, a difference of \$1,900.00 or 48% per month. During this period, BC-33 experienced on-going modifications as a direct result of the modernization program. Due to BC Rail's cost control system, an accurate identification and analysis of cost data for BC-33 is not possible.

4.7.3 Operating Costs - Fuel

BC Rail normally fuel the RDC cars at North Vancouver, Williams Lake and Prince George. Fuel consumption figures are recorded cumulatively for the total fleet of RDC's rather than by individual RDC unit.

A Fuel Consumption Survey conducted in May 1983, and shown in Appendix I, presents a reasonable indication of actual fuel consumption for BC-33 and the unmodernized RDC's.

Average Consumption

BC-33 (modified)	0.36 GPM (2.77 mpg)
RDC (unmodified)	0.34 GPM (2.92 mpg)

A second fuel survey was conducted during October 1, 1983 and October 15, 1983. This survey detailed the exact amount of fuel added to each RDC in service. All RDC cars were equipped with Cummins diesel engines.

For this survey, average fuel consumption was:

BC-33 (modified)	0.41 GPM (2.47 mpg)
RDC (unmodified)	0.39 GPM (2.56 mpg)

5.0 EVALUATION AND ASSESSMENT

Overall, the modernization program for BC-33 has been successful. The BC Rail objective was to provide a modernized passenger car which would cater to tourism. As indicated by the passenger survey, public acceptance of the modernized RDC has been excellent. Over 95% of the passengers indicated that they would like to travel again on the modernized RDC.

BC Rail have been satisfied with the performance and reliability of the modernized RDC and are continuing with their modernization program. It is estimated that the modification cost could be reduced by approximately 25% by eliminating or modifying some of the original modifications and by performing the work in the BC Rail Car Repair Shop in Squamish, British Columbia.

The majority of passengers indicated that the interior was very appealing or acceptable, with the exception of the non-retractable centre armrest, and the height of the seat-back which restricts visibility. Most passengers preferred the new seat and indicated that it was much more comfortable than the old seat. The seat-back and armrest will be redesigned on future modernization programs. In order to install aircraft-style seats and provide increased leg-room, seating capacity was reduced from 48 to 42 persons. The present seat configuration is considered to be the best arrangement possible, even though the view from some seats is partially blocked by the window support pillars.

The galley modifications appear to be satisfactory for preparing pre-cooked meals. Since BC Rail have not yet switched to the airline-style meals, the catering staff must cope with cooking conventional meals on the two electric burners and in the microwave oven. Galley comfort will be increased in future modifications by redesigning the overhead water tank to increase the ceiling height to 198 cm (6'6"), and by installing a small door in the baggage room bulkhead to enable supplies to be loaded directly into the galley.

The lavatory modernization is considered to be a partial success. Passengers have completely accepted the unisex lavatory concept because the lavatory has been enlarged by 50% and has been completely refurbished. On the other hand, the maintenance costs of the lavatory have increased substantially. The toilet is a prototype whereby the logic circuitry controls the flushing, chemical addition, maceration and dumping. BC Rail are still looking for an effective method of performing these operations reliably. On future installations, BC Rail will give consideration to simplification of operation and improved maintenance access. In view of increasingly stringent railway dumping regulations, further research is required to design a toilet for railway passenger operations.

The car heating and air conditioning systems function satisfactorily. The design, utilizing an auxiliary AC-power unit (APU) for the new AC powered air conditioning unit and galley operation, is considered to be practical. However, the two cycle engine chosen for this application is not acceptable due to the noise level and high maintenance costs. The APU constantly overheated or malfunctioned due to inadequate cooling at the top of the heads, or a blocked radiator or airborne track contaminants.

The APU has since been enclosed and connected to the power engine cooling system. These changes have reduced the number of occurrences of APU failure.

In view of the above, BC Rail have recently installed a smaller APU on BC-30 which was partially modernized. The existing 74 volt DC air conditioning system has been retained. Since only the modernized galley requires AC power, a smaller APU (Isuzu 8C244B, 25 kW) has been installed. This combination appears to operate reliably. For this reason, future modification programs should investigate the merits of using a 74-volt DC air conditioning system in conjunction with a smaller APU for the galley power versus the existing system utilized on BC-33.

The re-designed operator's cab and control console are considered optimum with the present operating controls and within the imposed space constraints. The installation of the electric heaters, the addition of overhead heating/air conditioning duct, and the adjustable locomotive-style seat increase operator comfort.

The design has had good acceptance by the engineers, with the exception of the single-handle throttle and braking controller. Since BC Rail operates a passenger service in one of the most demanding terrains in North America, with frequent braking and acceleration, the engineers prefer separate controls for the throttle and the brakes. The single controller has also proven to be a high maintenance item due to continual contamination of the circuitry controls.

BC Rail are investigating a modified console which would have controls for throttle as well as an automatic brake and an independent brake. They are considering installing No. 26 brake equipment with a WABCO 30-CDW brake valve similar to the brake control in new units. If this arrangement is adopted, the existing manual 'snow brake' would become redundant and could be eliminated.

The Cummins propulsion engines are excellent and reduce fuel consumption by approximately 16 percent. Safety systems have been modified to minimize potential serious damage. The twin-disc torque convertor and two-speed transmission are not reliable due to a higher than normal failure rate. Each failure costs approximately \$12,000.00 to rectify because the failed components usually destroy the hydraulic system.

Since the power train of BC-33 is the same as the other RDC's, in-service reliability of BC-33 is about the same as the other RDC's, with the exception of maintenance related to the APU. In terms of schedule adherence, there is no apparent difference between BC-33 and the other RDC's.

APPENDIX A - BC Rail Passenger Train Schedule

BRITISH COLUMBIA RAILWAY COMPANY PASSENGER TRAIN SCHEDULE No. 7

During period when Daylight Saving Time prevails in British Columbia, times for trains should be read as "Daylight Saving Time".

Effective June 3, 1984

Subject to change without notice.

TIME

The 24-hour clock is used to show arrival and departure times.

Example: 08:00 is 8 a.m.
12:00 is noon
18:30 is 6:30 p.m.
22:00 is 10 p.m.



RESERVED SEATS

Reserved seats (with or without meals) are required on all trains operating north of Lillooet (northbound on Sunday, Wednesday and Friday and southbound on Monday, Thursday and Saturday).

Reserved seats with meals are available on request at an additional charge. Reservations and payment must be made at least 48 hours prior to departure.

BUS SERVICE — VANCOUVER AND NORTH VANCOUVER

Daily bus service to B.C. Rail is available from Bus Depot at 150 Dunsmuir Street, Vancouver leaving at 6:40 a.m. Route will be via Georgia Street, Marine Drive and Pemberton Avenue. Pickups may be made from Bus Depot up to the entrance to Stanley Park. Buses meet train No. 2 at North Vancouver and return passengers to Vancouver via same route. Fares are \$1.00 each way per person, payable direct by passenger.

LIMOUSINE SERVICE is available at Prince George from Railway station to most city hotels and motels. Pick-up for southbound passengers will be made at the Inn of the North and the Simon Fraser Hotel at 06:45. Pick-up will be made at others only when passenger makes advance arrangements by calling Prince George Limousine Service (1981) Ltd., at 563-4044. This is an independent company and fares are payable direct by passenger.

NORTH VANCOUVER STATION is located at 1311 West 1st Street, V7P 1A7, Phone 984-5246.

PRINCE GEORGE STATION is located at 1108 Industrial Way V2N 2K8, Phone 564-9080.

VIA CONNECTION AT PRINCE GEORGE

B.C. Railway and VIA schedules now permit convenient connections between B.C. Railway and VIA to and from points East of Prince George.

BAGGAGE

Passengers may take into coaches only a reasonable quantity of hand baggage (no single piece to exceed 50 lbs. in weight), and are advised to check baggage not required en route. Unless otherwise stipulated, 150 pounds of baggage, not exceeding \$100 in value, 3 pieces per adult or 5 pieces per family, will be checked without charge on each adult passenger ticket and 75 pounds, not exceeding \$50 in value, for a child travelling on a half-fare ticket. Baggage exceeding these weights or values will be charged for at current rates, as will also any piece of baggage exceeding 45 inches in the greatest dimension. Baggage consists of wearing apparel, toilet articles and similar effects, except liquids, necessary for the comfort and convenience of the passenger on the journey. It is required to be enclosed in appropriate receptacles such as trunks, valises and so forth.

Combustible or inflammable material in baggage is prohibited by law, and must not be included therein.

RDC Trains provide only limited accommodation for the handling of checked baggage. Bulky piece or pieces weighing in excess of 75 lbs. will be forwarded in the first convenient train.

Dogs and small household pets, viz. cats, birds, etc., will not be checked for handling on the RDCs.

Baggage for Flag Stations where agents are not on duty must be claimed from Train Baggage-man before arrival at destination.

TICKETS

Conductors are not permitted to adjust fares. In the event of disagreement as to tickets, privileges allowed, etc., passenger should pay fare requested by the conductor and send his receipt to the Passenger Department for whatever adjustment may be due.

Children 12 years of age or over are required to pay full fare; children 5 years of age and under 12 pay half-fare. Children under 5 years of age travel free when accompanied by parent or guardian.

Seat Tickets. Children under 5 years of age will be required to pay full seat fare if occupying a seat in reserved seat car.

Read Down	Read Down					Read Up	Read Up
DAYLINER SUN. WED. FRI.	DAYLINER NO. 1 DAILY	MILES FROM NTH. VAN.	Km FROM NTH. VAN.	STATIONS	ALT.	DAYLINER NO. 2 DAILY	DAYLINER MON. THUR. SAT.
	0700	1.2	1.9	(S) NORTH VANCOUVER	3	2015	
	0720	11.6	18.6	HORSESHOE BAY	3	1948	
	0723	14.1	22.7	SUNSET BEACH	102	1938	
	0732	18.0	28.9	LIONS BAY	65	1934	
	0736	19.3	31.0	BRUNSWICK	36	1930	
	0748	26.2	41.5	PORTEAU CROSSING	16	1916	
	0757	31.0	49.9	BRITANNIA	13	1900	
	0814	39.9	64.2	(S) SQUAMISH	1	1940	
	0819	44.1	70.9	BRACKENDALE	76	1835	
	0826	49.7	80.0	CHEAKAMUS	189	1829	
	0842	59.5	95.7	GARIBALDI	1126	1809	
	0846	62.6	100.7	WATER TANK	1296	1806	
	0856	67.2	108.1	MCGUIRE	1632	1753	
	0910	73.4	118.1	WHISTLER	2184	1740	
	0912	74.4	119.7	ALTA LAKE	2199	1738	
	0913	75.0	120.7	CANADIAN HOSTEL	2199	1729	
	0918	77.2	124.2	MONS	2100	1728	
	0938	90.3	145.3	TISDALL	1123	1706	
	0950	94.7	152.4	(S) PEMBERTON	696	1700	
	0957	99.1	159.5	MT. CURRIE	686	1649	
	1001	109.0	175.4	GRAMSONS (10 Downing St.)	1303	1630	
	1019	113.7	183.0	BIRKEN	1575	1626	
	1027	117.8	189.5	GATES	1238	1617	
	1030	120.6	194.5	DEVINE	1015	1610	
	1035	122.8	197.6	D'ARCY	880	1607	
	1042	127.8	205.6	PONDEROSA	870	1555	
	1043	128.9	207.4	MCGILLIVRAY FALLS	872	1553	
	1052	130.4	209.8	MARNE	867	1551	
	1057	133.9	215.5	CURRIES	951	1542	
	1109	139.3	224.1	SETON PORTAGE	828	1536	
	1121	142.3	229.0	SHALATH	813	1528	
	1141	149.2	240.1	RETASKIT	815	1515	
	1210	157.5	253.4	(S) LILLOOET Lve.	973	1500	
	NO. 1 DAILY					NO. 2 DAILY	
	1220	157.5	253.4	Lve. (S) LILLOOET Arr.	793	1445	
	1233	1652	265.8	FOUNTAIN	1059	1423	
	1247	173.1	278.5	GLENFRASER	1666	1407	
	1256	177.8	286.1	PAVILION	2175	1356	
	1304	181.2	291.6	MORAN	2706	1345	
	1325	192.3	309.4	KELLY LAKE	3509	1325	
	1339	203.0	326.6	CLINTON	3166	1309	
	1346	214.6	345.3	CHASM	3508	1306	
				GREEN LAKE CROSSING			
	1403	223.2	359.1	AND 70 MILE	3568	1242	
	1416	230.5	370.9	GRAHAM		1234	
				GRVL. PIT - N. GREEN			
	1417	232.5	374.1	AND WATCH LAKES	3612	1231	
	1420	236.3	380.2	FLYING-U	3788	1226	
	1432	243.2	391.3	HORSE LAKE	3864	1218	
	1438	246.2	396.2	LONE BUTTE	3745	1213	
	1456	259.2	417.1	(S) EXETER	3181	1155	
	1505	265.4	427.1	TAITON	3041	1142	
	1516	273.4	440.0	LAC LA HACHE	2761	1132	
	1520	277.8	447.0	CANAMA	2658	1124	
	1528	281.5	453.0	WRIGHT	2660	1121	
	1546	293.6	472.5	ENTERPRISE	2500	1105	
	1610	305.8	492.1	ONWARD	2048	1046	
	1635	313.9	505.1	(S) WILLIAMS LAKE	1860	1027	
	1710	335.5	539.9	SODA CREEK	1755	0951	
	1728	346.5	577.6	MACALISTER	1603	0936	
	1741	358.1	576.3	ALEXANDRA	1800	0922	
	1817	384.6	618.9	(S) QUESNEL	1549	0848	
	1838	396.5	638.1	COTWOOD	2518	0829	
	1858	404.6	651.1	GREENING	2537	0818	
	1902	413.6	665.6	DUNKLEY	2215	0803	
	1904	419.3	674.8	STRATHNAVER	2080	0755	
	1917	424.6	683.3	HIXON	1964	0750	
	1924	430.9	693.4	WALKER	1856	0748	
	1950	448.8	722.2	REDROCK	2090	0720	
	2015	462.5	744.3	(S) PRINCE GEORGE	1870	0700	
DAYLINER SUN. WED. FRI.				(S) Denotes Agency and Regular Stop		DAYLINER MON. THUR. SAT.	
				(f) Denotes flag stop			

APPENDIX B - Revised General Specifications - BC-33



REVISED GENERAL SPECIFICATIONS

I. CAR BODY INTERIOR

A. Passenger Section

1. Strip interior entirely.
2. Replace all insulation.
3. Apply sub-floor to meet current standards.
4. Re-install existing wall and ceiling panelling except at centre ceiling.
5. Install new panelling in centre ceiling incorporating twin air conditioning diffusers.
6. Apply carpeting to floor and wall below lower window ledge. Aisle carpeting strip to be readily replaceable.
7. Apply vinyl or fabric (BC Rail to decide) to all ceiling and wall panels above lower window ledge.
8. Renew all window blinds and supply where missing.
9. Install aircraft-style, non-reversible, reclining seats in place of existing seats. Seat backs to incorporate fold-down food trays.
10. Replace existing baggage racks by new baggage racks that incorporate indirect fluorescent lighting to illuminate the coach ceiling, and individually controlled reading lights above each seat.
11. Provide options for a quality PA system in conjunction with movie projection facilities.

B. Food Facilities

1. Remove existing kitchen facility from RDC-3 and rebuild as per item 3 to 8 below.
2. Install snack bar facility in baggage area of RDC-1 as per items 4 to 8 below.
3. Install heated storage unit for approximately 100 trays of pre-cooked hot meals.
4. Install cold storage unit. Capacity to be specified by BC Rail.
5. Install one stainless steel bar sink complete with cold water supply from the car service water system.

6. Install food preparation and serving counters, and modular storage units as currently available and as approved by BC Rail.
7. Install power facilities and provide storage for two microwave ovens, an automatic ice maker and dispenser, and other small kitchen appliances to be specified.
8. Supply one food and beverage cart.
9. Present kitchen access door is considered overly restrictive; proposals for upgrading required.

C. Service Water System

1. Remove both lavatories from each car.
2. Install one large modular lavatory at the "B" end of each car.
3. Install one non-chemical retention type toilet with automatic dumping between stations.
4. Lavatory also to include all items normally supplied in such facility.
5. Recondition or replace water cooler and install at "B" end near lavatory.
6. Inspect entire service water system and repair or replace as required.

II. CAR BODY EXTERIOR

1. Thoroughly clean entire car body exterior including roof and under-car.
2. Inspect all structural, under-frame, equipment support, etc. members for corrosion or other damage, and repair or replace as required.
3. Remove all steam lines, hoses and equipment.
4. Inspect and repair or replace damaged portions of car body exterior.
5. Remove all existing lettering and paint trim.
6. Re-align and re-weatherstrip all doors.
7. Water test body and windows and repair any leaks.
8. Polish exposed stainless surfaces.
9. Apply lettering and paint trim as per BC Rail specifications.

10. Provide a roof mounted intermittent duty "Beacon" at leading end of car.

III. PROPULSION

1. Remove existing engine/transmission assemblies and replace with two Cummins NTA-855 diesel engine/twin disc transmission systems.
2. Clean, inspect and overhaul engine cooling systems. Modify as per Cummins package.
3. Clean, inspect and overhaul engine fuel systems.

IV. ELECTRICAL

1. Remove all wiring and replace with new wiring.
2. Inspect and repair or replace all conduit, fittings, boxes, race-way, etc.
3. Remove all electrical equipment and panels from car, and bench test and repair. Clean, repair or replace all coils, contactors, relay mechanisms, switches and circuit breakers. BC Rail to designate obsolete equipment for mandatory replacement.
4. Upgrade throttle controls.
5. Replace Rolokron anti-slide system with alternative to be specified by BC Rail.

V. AIR BRAKES

1. Upgrade selected air brake components to 26-C schedule as specified by BC Rail.
2. Upgrade compressor control system.

VI. OPERATING CAB

1. Remove operating cab and controls at "B" end of car completely.
2. Seal side and trap doors on operator side RDC-1.
3. Thoroughly seal and insulate cab area.
4. Provide adequate heating, ventilation and window defrosting.
5. Install permanently mounted and fully adjustable operator's seat.
6. Redesign control stand to include single handle controller for propulsion and braking. BC Rail to specify layout.
7. Install framing and bulkhead to close off operator area from vestibule when end door is in the open position.

VII. HEATING, VENTILATION AND AIR CONDITIONING

1. Inspect and repair or replace as required, all heating, ventilating and air conditioning thermostats, anemostats, valves and controls.
2. Replace all air filters and clean all air ducts and grills.
3. Replace all piping insulation.
4. Inspect and repair all heating piping and floor heat radiators.
5. Replace air conditioning system with dual 6-ton, 74 VDC system if available and if approved by BC Rail. In lieu of this, completely overhaul existing system and upgrade as necessary.

APPENDIX C - Passenger Survey Questionnaire

Sample Size

Survey 1 - 17 responses
2 - 14 responses
3 - 14 responses
4 - 10 responses

SURVEY - YOUR OPINION IS IMPORTANT!

Total 55 responses

Dear passenger: Seat No. _____

Your opinion is important...

BC Rail and VIA Rail are anxious to give you the best service possible. Your answer to these questions will be important in helping us to do so. An interviewer will collect questionnaires just before arrival.

The purpose of this survey is to evaluate the effectiveness of rebuilding and modernizing the fleet of self-propelled Budd Rail Diesel Cars (RDC's) operated in passenger service by BC Rail and VIA Rail Canada Inc.

This car, BC-33, has been completely modernized and we would value your opinion concerning ride quality, seating, baggage, interior aesthetics, food service and visibility, etc.

Please indicate your answer either by checking the box opposite the answer of your choice, or where applicable, by writing in your answers.

Thank you for your cooperation.

1. Have you previously ridden on the old RDC cars?

(i) ☐ yes 26 (47%) (ii) ☐ no 29 (53%)

2. Is this your first ride on the modernized RDC car?

(i) ☐ yes 44 (80%) (ii) ☐ no 11 (20%)

3. Before you arranged this trip, had you already heard about BC Rail's modernized car?

(i) ☐ yes 22 (40%) (ii) ☐ no 33 (60%)

4. What is the main purpose of your trip?

(i) ☐ business or work related 15 (27%) (ii) ☐ holiday or pleasure 40 (73%)

5. Why did you choose to travel on the car offering meal service?

(i) ☐ I wanted a meal 33% (More than 1 response)
(iii) ☐ better service 13% (ii) ☐ I wanted bar service 8%
(v) ☐ I wanted a reserved seat 26% (iv) ☐ the atmosphere is more relaxed 20%

6. Including this trip, how often have you travelled on BC Rail during the past 12 months?

	<u>One Time</u>	<u>Two Times</u>	<u>Three Times</u>
(i) ☐ times	39 - 71%	14 - 25%	2 - 4%

7. Are you travelling....

- (i) ☐ by yourself? 23 (42%) (ii) ☐ with another person? 24 (44%)
 (iii) ☐ with two or more people? 8 (14%)

8. What would you most prefer to do during this train trip? (Check two only)

- (i) ☐ sleep 4 (4%) (ii) ☐ work/write 7 (7%)
 (iii) ☐ read 20 (20%) (iv) ☐ eat/drink 14 (14%)
 (v) ☐ socialize 6 (6%) (vi) ☐ view scenery 48 (49%)

9. How have you used your seat tray?

- (i) ☐ to eat or drink on 51 (55%) (ii) ☐ to read on 12 (13%)
 (iii) ☐ to write on 29 (32%) (iv) ☐ have not used it
 (v) ☐ other (specify) _____

10. By now you have been on the RDC long enough to form a clear impression of the comfort level and on-board services provided by this modernized car. How do you think it compares with other means of travel?

Try to forget differences in ticket price. Think of how relatively enjoyable or relatively unpleasant you would find travelling in the RDC compared with travelling in the other types of transport. Check one box in (a), one in (b), and one in (c).

(a) RDC is ...

- (i) ☐ much better than auto 27 (49%) (ii) ☐ better than auto 14 (25%)
 (iii) ☐ about the same as auto 8 (15%) (iv) ☐ not as good as auto 6 (11%)
 (v) ☐ much worse than auto 0

(b) RDC is ...

- (i) ☐ much better than plane 10 (18%) (ii) ☐ better than plane 10 (18%)
 (iii) ☐ about the same as plane 15 (27%) (iv) ☐ not as good as plane 14 (25%)
 (v) ☐ much worse than plane 0 N/A 3 (6%)

(c) RDC is ...

- (i) ☐ much better than bus 41 (75%) (ii) ☐ better than bus 9 (16%)
 (iii) ☐ about the same as bus 2 (4%) (iv) ☐ not as good as bus 1 (4%)
 (v) ☐ much worse than bus N/A 1 (1%)

11. (a) Do you like the interior decor of the RDC?

- (i) ☐ yes, very appealing 34 (62%) (ii) ☐ yes, acceptable 20 (36%)
 (iii) ☐ not important 1 (2%) (iv) ☐ no, unappealing

(b) What do you associate the decor with? _____

12. How many pieces of luggage or parcels did you check onto the train?
(not counting purses or attache cases).

(i) — none	10 (18%)	(ii) — one	20 (36%)
(iii) — two	18 (33%)	(iv) — three	5 (9%)
(v) — more than three	2 (4%)	(vi) — backpack, skis	2

* relates to question (v)

13. (a) How often did you use the bar when travelling on other types of trains?

(i) — always	3 (5%)	(ii) — often	2 (4%)
(iii) — sometimes	20 (36%)	(iv) — never	24 (44%) N/A 6 (11%)

13. (b) The RDC has no separate bar car. Do you consider this a drawback?

(i) — not at all, I like to be served at my seat	22 (40%)	(ii) — it is not important	26 (47%)
(iii) — it is a slight disadvantage	4 (7%)	(iv) — yes, a serious drawback	3 (6%)

14. (a) Would you prefer information on the public address system on the train?

(i) — yes	30 (55%)	(ii) — no	25 (45%)
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- (b) Would you prefer music?

(i) -- yes	24 (44%)	(ii) — no	31 (56%)
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15. How would you rate these other features of the modified RDC?

Based upon 55
responses to
each question.

	Seat Tilt Angles	Leg Room	Overhead Compartment	Washroom	Ashtray
exceptionally good	1 <u>40%</u>	1 <u>51%</u>	1 <u>51%</u>	1 <u>31%</u>	1 <u>15%</u>
acceptable	2 <u>56%</u>	2 <u>45%</u>	2 <u>38%</u>	2 <u>53%</u>	2 <u>11%</u>
indifferent	3 —	3 <u>3%</u>	3 <u>2%</u>	3 <u>2%</u>	3 <u>9%</u>
needs modification	4 —	4 <u>1%</u>	4 <u>4%</u>	4 <u>5%</u>	4 <u>5%</u>
completely unacceptable	5 —	5 —	5 —	5 —	5 —
did not use	6 <u>4%</u>	6 —	6 <u>5%</u>	6 <u>9%</u>	6 <u>60%</u>

- * Front seats did not have fold-down trays.
Portable insert trays were used.

...and how would you rate these features of the RDC?

Based upon 55 responses to each question.	Seat Tray Size	Seat Tray Operation	Window Visibil- ity	Blinds	Lighting
exceptionally good	1 <u>24%</u>	1 <u>31%</u>	1 <u>56%</u>	1 <u>20%</u>	1 <u>29%</u>
acceptable	2 <u>68%</u>	2 <u>55%</u>	2 <u>29%</u>	2 <u>31%</u>	2 <u>44%</u>
indifferent	3 <u>2%</u>	3 <u>6%</u>	3 <u> </u>	3 <u>2%</u>	3 <u>2%</u>
needs modification	4 <u>2%</u>	4 <u>4%</u>	4 <u>2%</u>	4 <u> </u>	4 <u> </u>
* completely unacceptable	5 <u>2%</u>	5 <u> </u>	5 <u>11%</u>	5 <u> </u>	5 <u> </u>
did not use	6 <u>2%</u>	6 <u>4%</u>	6 <u>2%</u>	6 <u>47%</u>	6 <u>25%</u>

16. How comfortable do you find the modified RDC seat compared with seats on other cars you have taken on this route?
- (i) 36% RDC seat is much better (ii) 20% RDC seat is better
(iii) 4% RDC seat is about the same (iv) RDC seat is worse
(v) RDC seat is much worse (vi) 40% cannot make comparison
17. How does the ride of the modernized RDC compare with other cars you have taken on this route? (smoothness, rocking motion, vibration, noise etc.)
- (i) 16% RDC ride is much better (ii) 18% RDC is better
(iii) 15% RDC ride is about the same (iv) 2% RDC ride is worse
(v) RDC ride is much worse (vi) 49% cannot make comparison
18. Overall, how does the comfort and service on the modernized RDC compare with other railway cars or buses you have taken on this route?
- (i) 35% RDC is much better (ii) 24% RDC is better
(iii) 2% RDC is about the same (iv) 2% RDC is worse
(v) RDC is much worse (vi) 37% cannot make comparison
19. What do you think of the air conditioning/heating at your seat? (Check appropriate boxes.)
- (i) 10% too warm (ii) 4% too cold
(iii) too humid (iv) 2% too dry
(v) 7% too drafty (vi) 7% too smokey
(vii) 70% no complaints

20. (a) In your opinion, what are the best aspects of BC Rail's new car?

The pleasant interior.

(b) What are the "worst" aspects?

Most people did not have any "worst" aspects.

21. Would you take this trip again?

(i) on the modernized RDC?

95% yes 5% no

(ii) on the old RDC?

24% yes 25% no

N/A 51%

THANK YOU!

APPENDIX D - Temperature Record

TEMPERATURE ANALYSIS

RDC EVALUATION - TEMPERATURE RECORD

Date of Test: August 26, 1983

(1) Code: C - Coach
G - Galley
O - Operator

First Test Run

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
07:50	North Vancouver	-	BC33-C	22.0	Mid car position.
			BC33-G	-	
			BC33-O	-	
			BC12-C	21.5	21.0 at B end.
08:30	Porteau Crossing	17.0	BC33-C	27.0	
			BC33-G	29.0	
			BC33-O	19.0	
			BC12-C	23.0	22.0 at B end.
09:00	Brackendale	17.0	BC33-C	27.0	
			BC33-G	29.0	
			BC33-O	17.0	Window and door open.
			BC12-C	23.0	22.0 at B end.
09:30	Brandywine Falls	17.0	BC33-C	27.0	
			BC33-G	29.0	
			BC33-O	18.0	
			BC12-C	23.0	22.0 at B end.
10:00	Whistler	-	BC33-C	-	Temperature control knob
			BC33-G	-	was midway between cold
			BC33-O	-	and warm.
			BC12-C	-	No personnel monitoring
					temperature. Requested
					staff to adjust knob to
					colder position.
10:39	Pemberton	22.0	BC33-C	28.0	
			BC33-G	30.5	
			BC33-O	22.0	
			BC12-C	24.0	22.5 at B end.
11:00	Birken	22.0	BC33-C	22.0	22.0 at Seat #41, galley
			BC33-G	-	curtain.
			BC33-O	22.0	
			BC12-C	24.0	23.0 at B end.

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
11:30	D'Arcy	23.0	BC33-C	24.5	24.5 at Seat #41.
			BC33-G	27.0	
			BC33-O	23.0	
			BC12-C	24.5	23.0 at B end.
12:26	Retaskit	24.5	BC33-C	22.0	23.5 at Seat #41.
			BC33-G	24.5	
			BC33-O	-	
			BC12-C	23.0	23.0 at B end.
13:00	Lillooet	32.0	Sun		
		29.0	Shade		

TEMPERATURE ANALYSIS

RDC EVALUATION - TEMPERATURE RECORD

Date of Test: August 26, 1983 (Return Trip)

(1) Code: C - Coach
G - Galley
O - Operator

First Test Run

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
15:30	Lillooet	34.0	BC31-C BC31-G BC31-O	27.0 34.0 32.0	One burner "on" with coffee pot.
16:00	Shalalth	31.0	BC31-C BC31-G BC31-O	27.5 34.0 -	
16:30	McGillivray Falls	30.0	BC31-C BC31-G BC31-O	27.0 32.0 -	
17:00	Gates	29.0	BC31-C BC31-G BC31-O	26.5 31.0 -	
17:30	Pemberton	31.0	BC31-C BC31-G BC31-O	26.5 32.0 -	
18:00	Mons	25.5	BC31-C BC31-G BC31-O	26.0 28.0 22.0	

- * No galley service.
- * No reserved seating.

TEMPERATURE ANALYSIS

RDC EVALUATION - TEMPERATURE RECORD

Date of Test: October 20, 1983

(1) Code: C - Coach
G - Galley
B - Baggage
O - Operator

Second Test Run

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
07:35	North Vancouver	15.0	BC33-C BC33-G BC33-O BC12-C	21.5 23.5 23.0 21.0	21.5 at Seat #41.
08:00	Sunset Beach	14.0	BC33-C BC33-G BC33-O BC12-C	23.0 23.0 23.5 23.5	23.0 at Seat #41.
08:30	Porteau Crossing	14.5	BC33-C BC33-G BC33-O BC12-C	24.0 24.0 23.5 24.0	24.0 at Seat #41.
09:00	Brackendale	11.0	BC33-C BC33-G BC33-O BC12-C	24.0 24.0 23.0 24.0	24.0 at Seat #41.
09:39	Water Tank	10.5	BC33-C BC33-G BC33-O BC12-C	23.5 24.0 23.0 23.0	24.0 at Seat #41.
10:00	Whistler	10.0	BC33-C BC33-G BC33-O BC12-C	23.0 - 23.0 24.0	23.0 at Seat #41.
10:30	Tidsdall	-	BC33-C BC33-G BC33-O BC12-C	24.0 25.0 24.5 24.0	24.0 at Seat #41.

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
11:00	Mt. Currie	10.5	BC33-C	24.0	24.0 at Seat #41.
			BC33-G	24.0	
			BC33-O	24.0	
			BC12-C	24.5	
11:30	D'Arcy	12.5	BC33-C	24.0	24.0 at Seat #41.
			BC33-G	24.0	
			BC33-O	24.0	
			BC12-C	25.0	
12:00	Seton Portage	13.0	BC33-C	24.0	24.5 at Seat #41.
			BC33-G	25.0	
			BC33-O	24.0	
			BC12-C	25.0	
12:30	Lillooet	15.0			

TEMPERATURE ANALYSIS

RDC EVALUATION - TEMPERATURE RECORD

Date of Test: December 9, 1983

(1) Code: C - Coach
G - Galley
B - Baggage
O - Operator

Third Test Run

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
07:39	North Vancouver	6.0	BC33-C	24.0	
			BC33-G	23.0	
			BC33-O	-	Open windows.
			BC10-C	25.0	Mid car position.
08:00	Sunset Beach	6.0	BC33-C	25.0	
			BC33-G	23.5	
			BC33-O	-	
			BC10-C	22.5	
08:36	Britannia	5.0	BC33-C	25.5	
			BC33-G	24.0	
			BC33-O	-	
			BC10-C	26.0	
09:00	Brackendale	3.0	BC33-C	26.0	
			BC33-G	24.0	
			BC33-O	-	
			BC10-C	26.0	
09:30	Brandywine Falls	3.5	BC33-C	26.0	
			BC33-G	23.0	
			BC33-O	-	
			BC10-C	26.0	
10:00	Whistler	1.0	BC33-C	26.5	
			BC33-G	23.5	
			BC33-O	-	
			BC10-C	26.5	
10:30	Tidsdall	-1.0	BC33-C	26.0	Draft at rear door of
			BC33-G	-	BC33, 16.0°C.
			BC33-O	-	
			BC10-C	26.5	

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
11:00	Mt. Currie	0.0	BC33-C	26.0	6.0°C on floor, 1' from rear door.
			BC33-G	25.0	
			BC33-O	-	
			BC10-C	26.0	
11:30	Devine	-1.0	BC33-C	25.0	7.0°C behind Seat #1, approximately 3' from rear door.
			BC33-G	24.5	
			BC33-O	-	
			BC10-C	26.0	
12:00	Curries	0.0	BC33-C	25.0	9.0°C behind Seat #1.
			BC33-G	25.0	
			BC33-O	-	
			BC10-C	-	
12:30	Shalalth	-1.0	BC33-C	25.0	10.0°C behind Seat #1.
			BC33-G	24.0	
			BC33-O	-	
			BC10-C	26.0	

TEMPERATURE ANALYSIS

RDC EVALUATION - TEMPERATURE RECORD

Date of Test: February 22, 1984

(1) Code: C - Coach
G - Galley
B - Baggage
O - Operator

Fourth Test Run

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
07:30	North Vancouver	7.0	BC33-C BC33-G BC33-O BC12-C	22.0 23.0 24.5 -	
08:00	Lions Bay	5.0	BC33-C BC33-G BC33-O BC12-C	21.0 24.5 15.0 24.5	Open windows in operators cab, door closed.
08:30	Porteau Crossing	7.0	BC33-C BC33-G BC33-O BC12-C	22.0 24.5 - 23.0	
09:00	Squamish	7.0	BC33-C BC33-G BC33-O BC12-C	21.0 24.5 - 23.0	
09:30	Garibaldi	3.5	BC33-C BC33-G BC33-O BC12-C	21.0 24.0 - 23.0	
10:30	Tidsdall	2.0	BC33-C BC33-G BC33-O BC12-C	21.0 24.0 - 23.0	
11:00	Birken	4.5	BC33-C BC33-G BC33-O BC12-C	23.0 - - 21.0	14.0°C by seat at back door. Poor alignment of door and poor weather-stripping.

<u>Time</u>	<u>Geographic Location</u>	<u>Ambient °C Temperature</u>	<u>Coach Location (1)</u>	<u>°C Temperature</u>	<u>Notes</u>
11:30	D'Arcy	5.0	BC33-C	21.0	Preparing lunch.
			BC33-G	26.0	
			BC33-O	-	
			BC12-C	23.0	
12:00	Seton Portage	9.0	BC33-C	21.0	
			BC33-G	25.0	
			BC33-O	-	
			BC12-C	22.0	
12:30	Near Lillooet	9.5	BC33-C	21.5	
			BC33-G	25.0	
			BC33-O	-	
			BC12-C	22.0	

APPENDIX E - Vibration and Noise Testing Overview

BC RAIL - RAIL DIESEL CAR EVALUATION

Vibration and Noise Testing Overview

OBJECT

To test, by objective measurement, the vibration and noise environments in passenger areas of specified RDC units under BC Rail service.

INSTRUMENTATION

- 1) Vibration Meter, General Radio Co., Type 1553A, and piezoelectric accelerometer G.R., Type 1560 P52, having frequency response 2 to 2,000 hz; fully portable with self contained batteries.

Pretest calibration performed: calibrator G.R., type 1557A excitation 1g rms at 100 hz, vibration meter peak-to-peak acceleration response adjusted to 1,090 inches per second squared.

- 2) Sound Level Meter, General Radio Co., Type 1933, and ANSI/IEC specification flat random incidence response microphone. Pretest calibration performed: calibrator G.R., Type 1562A; sound level meter weighting A decibel response adjusted.

The choice of the above portable, direct reading instruments for "overview tests" is consistent with budget-wise engineering practice.

TEST LOCATIONS

<u>Rail Diesel Car</u>	<u>Forward</u>	<u>Mid-car</u>	<u>Rear</u>
BC-33 modified, with APU 44 passenger	-	Seat #86	Seat #2
BC-12 unmodified 86 passenger	Seat #86	-	Seat #10
BC-31 unmodified 44 passenger	-	Seat #37	Seat #1

All test locations above are aisle seats; the accelerometer was fastened to the seat support structure through use of a magnet facilitating re-orientation for sensing either vertical or lateral vibration. For sound level readings, the extended microphone was held horizontally 4' above the floor.

The choice of these test locations reflect typical practice in RDC ride quality evaluation.

VIBRATION AND NOISE MEASUREMENTS

Ride quality tests were conducted aboard BC Rail's RDC train on Friday, August 26, 1983, specifically on RDC BC-33 and BC-12 during a morning north-bound run between North Vancouver and Lillooet, and on BC-31 during an afternoon south-bound run between Lillooet and North Vancouver.

The tables list the data obtained; vibration in inches per second squared peak-to-peak acceleration and audible noise in decibels weighting A. These measurement samples were taken at random. Exceptions are noted in the remarks column.

OBSERVATIONS

Some observations may be made re: the data from this overview run:

- 1) Sound level readings for the unmodified RDC revealed impulsive noise, whereas those for the modified RDC were relatively steady.
- 2) In preparation for the second run, consideration should be given for limited octave band analysis to yield better definition of acoustic factor in passenger ride quality.
- 3) Vibration transients occurred during travel on curved sections of track.
- 4) Vibration levels increased during periods of train acceleration.
- 5) The vibration acceleration values for the vertical direction generally exceeded that for the lateral direction.
- 6) It is to be noted that a time of day was recorded for each sample measurement; this in accord with the test plan adopted at the commencement of the run; this plan called for the use of BC Rail documentation to provide the desired speed data from correlation with time of day. Continuous braking and acceleration of the train, departures from schedule, and document deficiencies rendered this plan ineffective. In preparation for the second run, consideration should be given to a simple provision for speed information.

RIDE QUALITY ASSESSMENT - CURSORY AND TENTATIVE

- 1) Selected objective noise tolerance criteria for passenger ride quality - Amtrak noise limit specification for passenger conversation activity **74 dB(A)**. (Reference: R. Higginbotham, "Ride Quality Evaluation," Transportation Research Record 894).

For the preliminary overview test run on August 26, 1983, an assessment of passenger area noise, based on noise excesses relative to the above criteria, found few excesses and no significant difference between modified (BC-33) and unmodified RDC.

- 2) Selected objective vibration tolerance criteria for passenger ride quality; body discomfort - acceleration threshold (ignoring qualifying factors) **200** inches per second squared peak-to-peak acceleration. (Reference: G.R. Allen, "Vibration Requirements for Ride Quality," Transportation Research Record 894).

For straight track travel during the preliminary overview test run of August 26, 1983, an assessment of passenger area vibration based on vibration excesses relative to the above criteria found few excesses and no significant difference between modified (BC-33) and unmodified RDC. Vibration samples for curved track travel did exceed the discomfort criteria.

RECOMMENDATION FOR SECOND TEST RUN

The preliminary overview run revealed:

- 1) Differences in the character (and passenger tolerance) of the noise in the two types of RDC's. Note: The unmodified RDC exhibited impulsive noise, rapidly changing in level or magnitude.
- 2) Vibration transients of significant magnitude during curved track travel and during periods of train accelerations.

A second run should be planned to provide for acquisition of pertinent data and for the full evaluation and comparison of ride quality for the two types of RDC's.

BC-33

Time	Mid-car			Rear			Remarks
	Vertical Acceln.	Lateral Acceln.	Noise dBA	Vertical Acceln.	Lateral Acceln.	Noise dBA	
0750	80	60	73				In tunnel
0756			68				
0823	60	50	68				
0828				110	80	70	
0857	160	100	72				45 mph
0900	100	80					
0904	80	50	70				
			88 dBA in baggage room above APU with outside door open.				
			76 dBA in galley entry.				
0912	80-100						
0915	70	50					
	80-90	60-70					
0918				100	100		
0920					60		< 25 mph
0924				150	100		
				200	150		Train accelerating
0928						71	
0929				150	300		Curve
0930				150			
				300			Curve
0935						65	Halt
0937				160	100	68	
				300	200 +		Curve
1003	90	50					
1007	90	50					
1011	70	40					
1015						68	

BC-33

Time	Mid-car			Rear			Remarks
	<u>Vertical Acceln.</u>	<u>Lateral Acceln.</u>	<u>Noise dBA</u>	<u>Vertical Acceln.</u>	<u>Lateral Acceln.</u>	<u>Noise dBA</u>	
1020			67			69	
1029						67	
1030			67				
1032			65.5				
1051				150	70		Halt
1053				200	100		Curve
1100	110	100					2% upgrade
1111	70	50					
1115				100	80		
1136		30					
		70 +					Curve
1139	50						
1140	50						
1141	100						Halt
1153	50	40					Curve
1240	Noise tests, external, left side of halted train, traction motors idling.						
a)	4' from BC-33, APU location - midpoint of side of RDC: 93 dBA						
b)	3' from BC-33, forward traction motor air vent: 98 dBA						
c)	4' from BC-10, (no APU) = midpoint of side of RDC: 80 dBA						

BC-12

Time	Mid-car			Rear			Remarks
	<u>Vertical Acceln.</u>	<u>Lateral Acceln.</u>	<u>Noise dBA</u>	<u>Vertical Acceln.</u>	<u>Lateral Acceln.</u>	<u>Noise dBA</u>	
0832	100	100	70				
0839	100	100					
0842				110	100	69	
0852				120	80	73	Whistle
				200 +	120 +		Curve
1021			69			62-68	
1025						73	Whistle

BC-31

Time	Mid-car			Rear			Remarks
	<u>Vertical</u> <u>Acceln.</u>	<u>Lateral</u> <u>Acceln.</u>	<u>Noise</u> <u>dBA</u>	<u>Vertical</u> <u>Acceln.</u>	<u>Lateral</u> <u>Acceln.</u>	<u>Noise</u> <u>dBA</u>	
1627	100	70					
1631				180			
				220			Curve
1633				100	100		
1635				150	100		
1637				120			
1639			68				
1641			67-75				Party conversation
1647	190						45 mph
1648	150	100					
1655	100	80					
	200						Curve
			75				Party conversation
1717	100-150	60					
1736	200	200					
1739	230	120					Curve
1745	150	100					
1748	130	80					
1750				120			
				220	130		Curve
1752					100		
					200		Curve
1753				150			
				200			Curve
1755				130	100		
				180 +			Curve
1800			83				Whistle
1802			69				Lull
1902	110	50					
	180	80					Train accelerating
1908			73				Party conversation
1943	80	60					

APPENDIX F - Rail Diesel Car Vibration Ride Quality Test

RAIL DIESEL CAR VIBRATION

RIDE QUALITY TEST

Prepared For:

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Date:

November 30, 1983

OBJECT

To measure the lateral acceleration parameter of vibration in passenger areas of two Rail Diesel Cars (RDC) in British Columbia Railway service and to assess the ride quality in terms of "reduced comfort boundary" criteria and the rating method described in the International Standard ISO-2631-1978, "Guide to the Evaluation of Human Exposure to Whole-body Vibration" and Amendment 1 (1982).

TEST CARS

The two rail diesel cars tested in this investigation are part of the fleet of self-propelled Budd cars operated in passenger service by BC Rail. These two RDC's, BC-33 and BC-12, have identical suspensions and propulsion engines.

In 1982, BC-33 was modified, fitted with modern galley, auxiliary power unit, and its interior refurbished for 44 passenger capacity. Its modified weight is 131,400 lbs. BC-12 remains unmodified with a passenger capacity at 86, and a weight of 118,000 lbs.

TEST ARRANGEMENTS

Vibration testing took place on October 26, 1983 during a regular 5 hour run with departure from North Vancouver at 07:30 hours for Lillooet, a route distance of 157.5 miles. Curved track is prevalent along this route; train acceleration and braking are frequent, while speeds in excess of 45 mph are rare and of short duration.

RDC BC-33 was the lead unit in a four unit train. BC-12 was the second unit in the train and was coupled to BC-33. Two accelerometers were oriented for lateral direction vibration and fastened by magnet to the support structures of passenger aisle seats, one at Seat #2 at the rear of BC-33, and one at Seat #86 at the forward end of BC-12.

INSTRUMENTATION AND DATA ACQUISITION

The vibration transducer signal channel for BC-33 comprised a piezo-electric accelerometer, Bruel & Kjaer Type 4370, and a vibration meter, Bruel & Kjaer Type 2511. The signal channel for BC-12 comprised a second type 4370 accelerometer, 40 feet of low noise coax cable and amplifier, Bruel & Kjaer Type 2635. The responses of these two combinations were verified at the 1 g level in a preliminary test using the accelerometer calibrator, Bruel & Kjaer Type 4291.

An instrumentation tape recorder, TEAC model R70, provided two frequency modulation mode channels with band-pass 0 to 600 hz for 1-7/8 ips tape speed. The input/output signal gain of the tape recorder was measured in a laboratory test. A third recorder channel served for voice annotation and information such as train speed and route milepost identification. Event identification was facilitated by the recorder's tape exposure counter. During the test run, all instrumentation was powered from self contained batteries.

VIBRATION ANALYSIS

The tapes were played back at a speed of 1-7/8 ips, the recording speed. The recorder output was connected to a real-time universal waveform analyzer, Nicolet Scientific Corporation Model 100A which features fast Fourier transform, 0.25 hz band width, digital storage, and capability for display, measurement and averaging in either frequency or time domains. An inkless continuous paper video plotter, Nicolet Model 132A, was engaged to produce permanent records of analyzer CRT screen displays.

Approximately 100 minutes of taped record were displayed on the analyzer CRT screen for visual examination of acceleration time function waveform and narrow band frequency spectra for lateral direction vibration at passenger seats in the modified, BC-33, and the unmodified, BC-12, rail diesel cars.

Evaluation procedures, instrumentation and data acquisition conformed to the International Standard already cited. Amendment 1 of the Standard specifies the determination of the acceleration signal crest-factor, the ratio of the unweighted maximum peak value to the weighted root-mean-square (rms) value evaluated over a period not less than one minute. Table 3 of the ISO Standard details the weighting applicable to lateral (transverse a.) direction acceleration signals. Accordingly, representative samples (each of 1 minute duration) of vibration for both tangential and curved track were processed for the determination of signal crest factors.

The International Standard provides for the assessment of ride quality by defining "reduced comfort boundaries" outlined in graphs of acceleration against frequency expressed in one third octave bands. Each comfort boundary is specified by the endurance time in minutes or hours before ride comfort is reduced enough to produce unpleasant sensations and/or physical fatigue for the average passenger.

Accordingly, representative samples of ride vibration were processed by the analyzer to yield narrow band (0.25 hz band width) rms acceleration spectra (0.25 to 100 hz range) evaluated over a period of one minute. These narrow band spectra were then processed by computer and converted to one third octave band spectra. The one third octave band spectra were plotted on ISO charts of "reduced comfort boundary" graphs appropriate to lateral (transverse a.) direction acceleration. The combination of spectrum and ISO graphs yields ride quality rating in terms of endurance time.

RIDE QUALITY TEST RESULTS

Figure 1 displays lateral acceleration time function graphs representative of the ride performance of the two rail diesel cars. Each graph exhibits 7 seconds of real time vibration. These graphs reveal RDC vibration levels for curved track significantly greater than those for tangential track on the Vancouver-Lillooet run.

RDC vibration crest factors were below 4 for tangential track and below 5 for curved track. The finding of crest factors within the Standard's upper limit of 6 establishes the suitability of the ISO 2631 rating procedures for ride quality assessment of the RDC vibration.

Figure 2 displays lateral acceleration spectra representative of RDC ride performance on tangential track, sampled in the vicinity of milepost 45 for a train speed of approximately 50 mph. These are narrow band (0.25 hz band width) rms acceleration spectra (0.25 to 100 hz range) evaluated over a period of one minute.

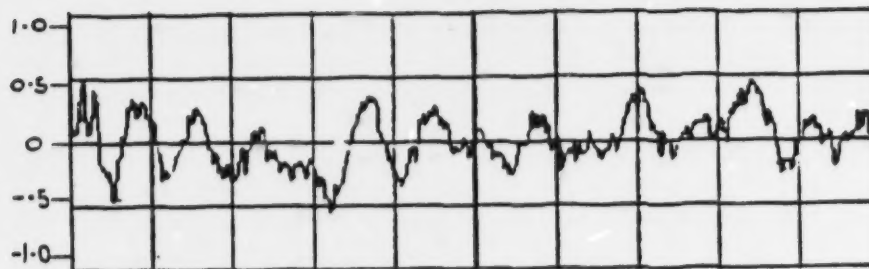
Figure 3 displays lateral acceleration spectra representative of RDC ride performance on curved track, sampled in the vicinity of milepost 52 for a train speed of approximately 30 mph. These are narrow band (0.25 hz band width) rms acceleration spectra (0.25 to 100 hz range) evaluated over a period of one minute.

Figure 4 displays a ride quality rating graph for the performance of the modified BC-33 RDC on tangential track; an 8 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

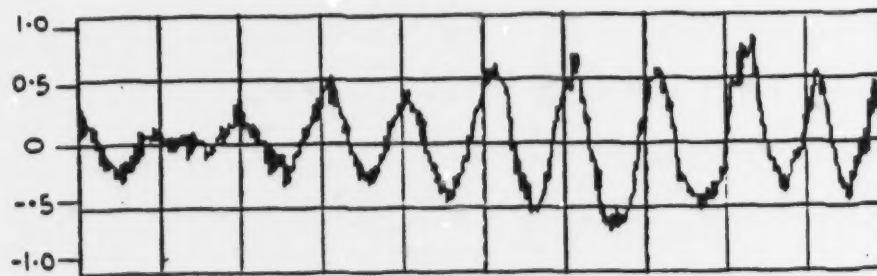
Figure 5 displays a ride quality rating graph for the performance of the unmodified BC-12 RDC on tangential track; an 8 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

Figure 6 displays a ride quality rating graph for the performance of the modified BC-33 RDC on curved track; a 2.5 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.

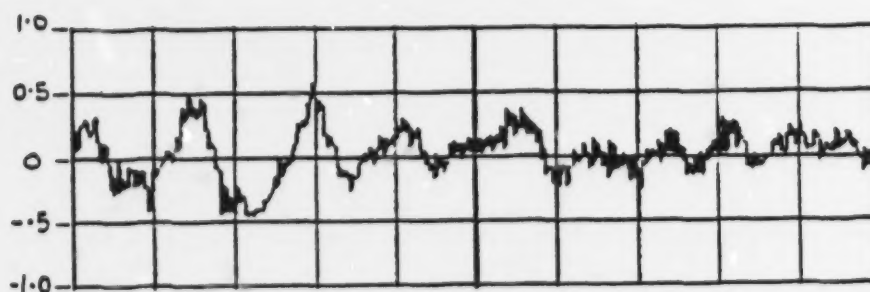
Figure 7 displays a ride quality rating graph for the performance of the unmodified BC-12 RDC on curved track; a 4 hour endurance ISO rating results with the identification of the most significant "reduced comfort boundary" exceeded by the spectrum for the representative vibration.



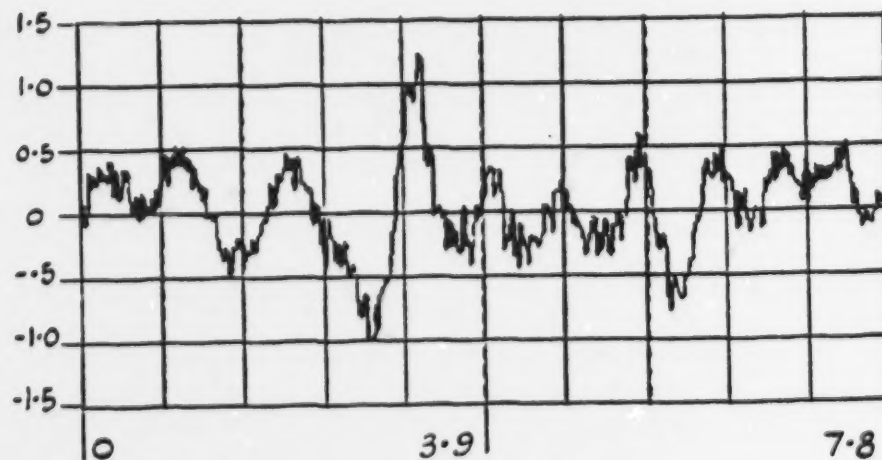
BC-33 (Modified RDC) on Tangential Track



BC-33 (Modified RDC) on Curve



BC-12 (unmodified RDC) on Tangential Track



BC-12 (unmodified RDC) on Curve

Time (Secs.)

FIGURE 1 - TYPICAL ACCELERATION TIME HISTORIES

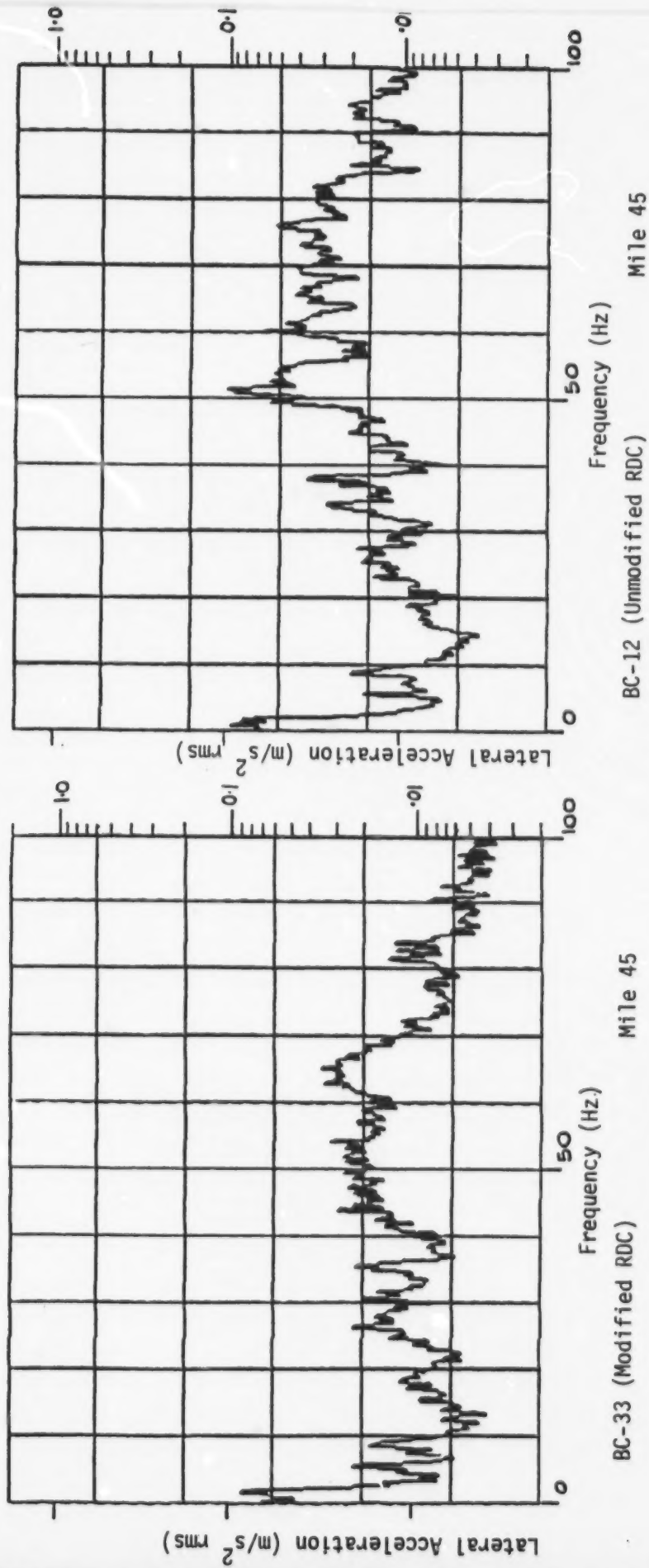


FIGURE 2 - AVERAGED LATERAL ACCELERATION SPECTRA TANGENTIAL TRACK

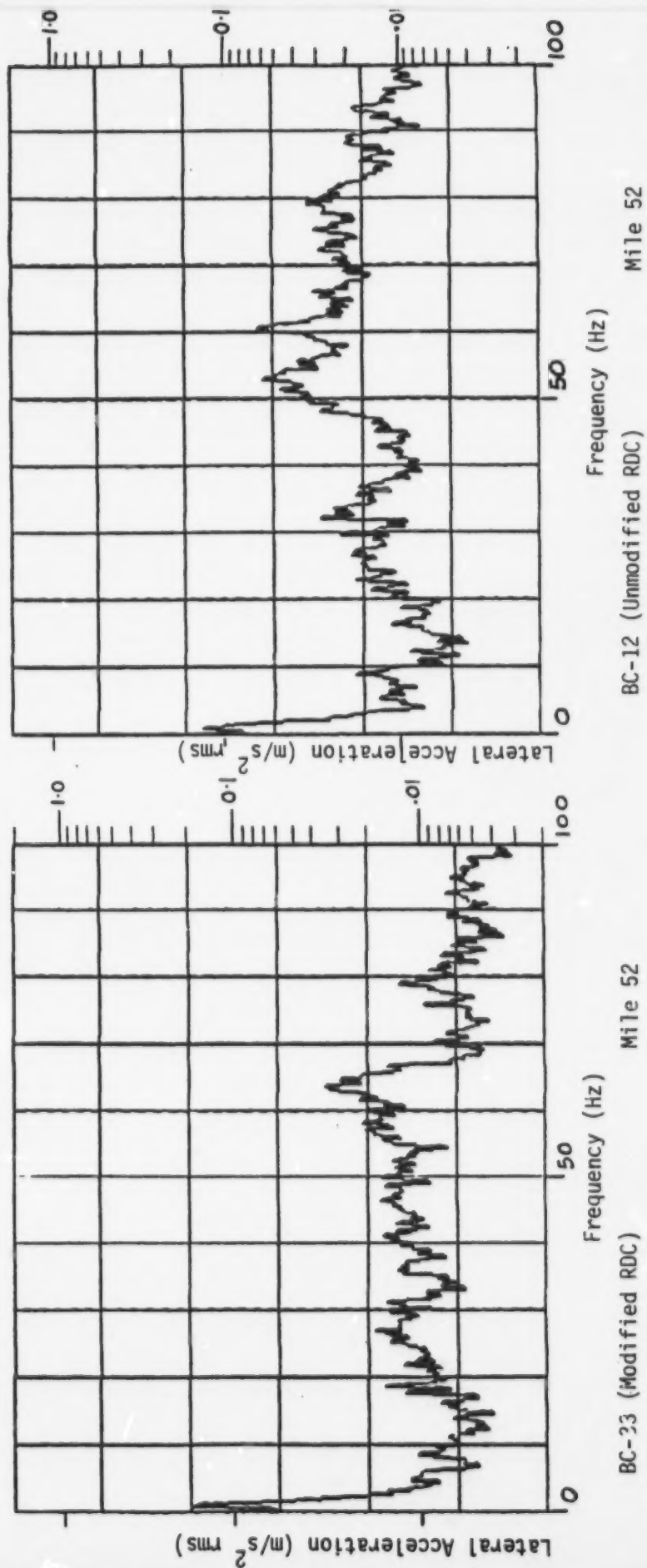


FIGURE 3 - AVERAGED LATERAL ACCELERATION SPECTRA CURVED TRACK

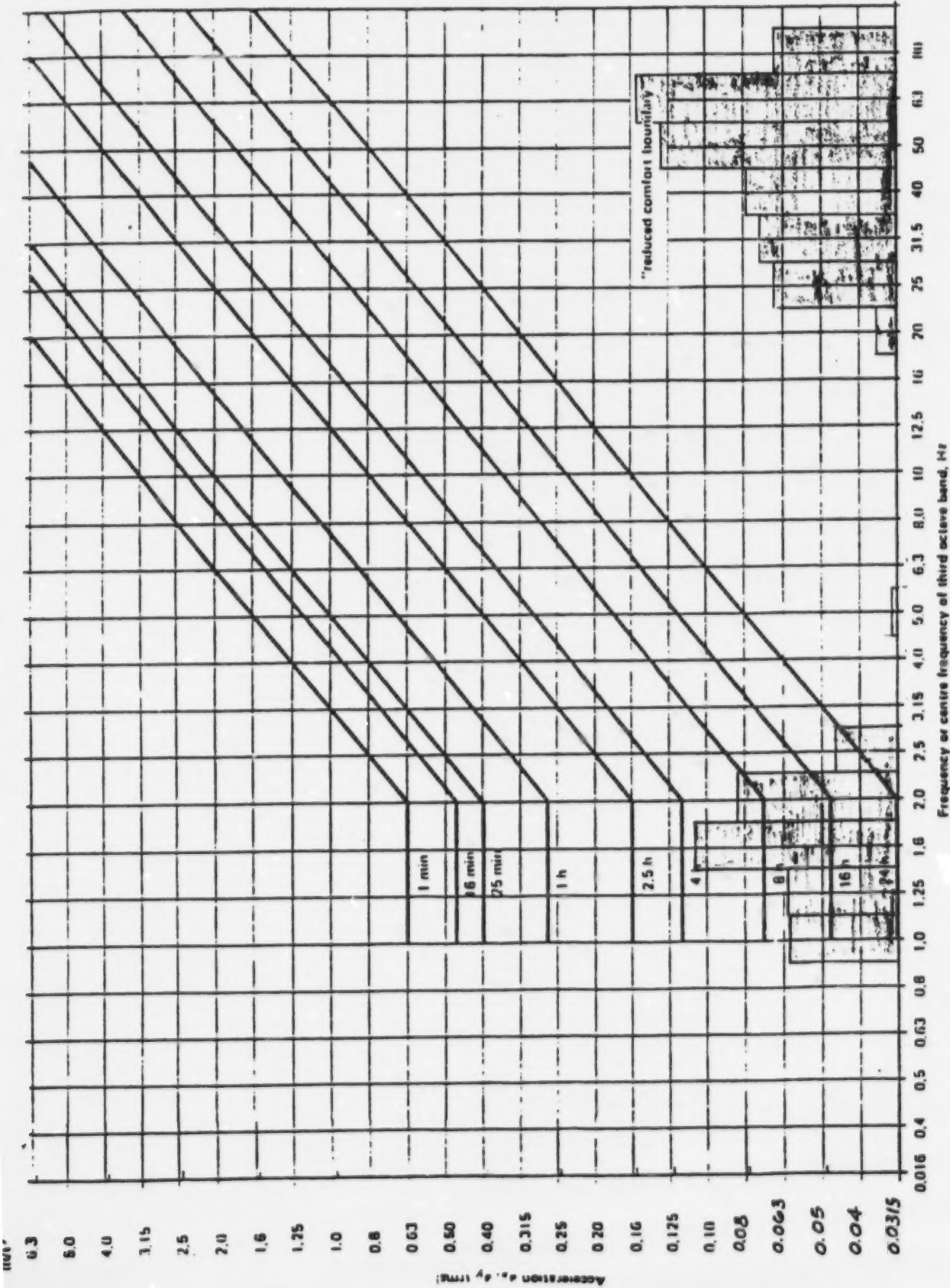


FIGURE 4 - ISO RIDE QUALITY BC-33 (MODIFIED RDC) ON TANGENTIAL TRACK

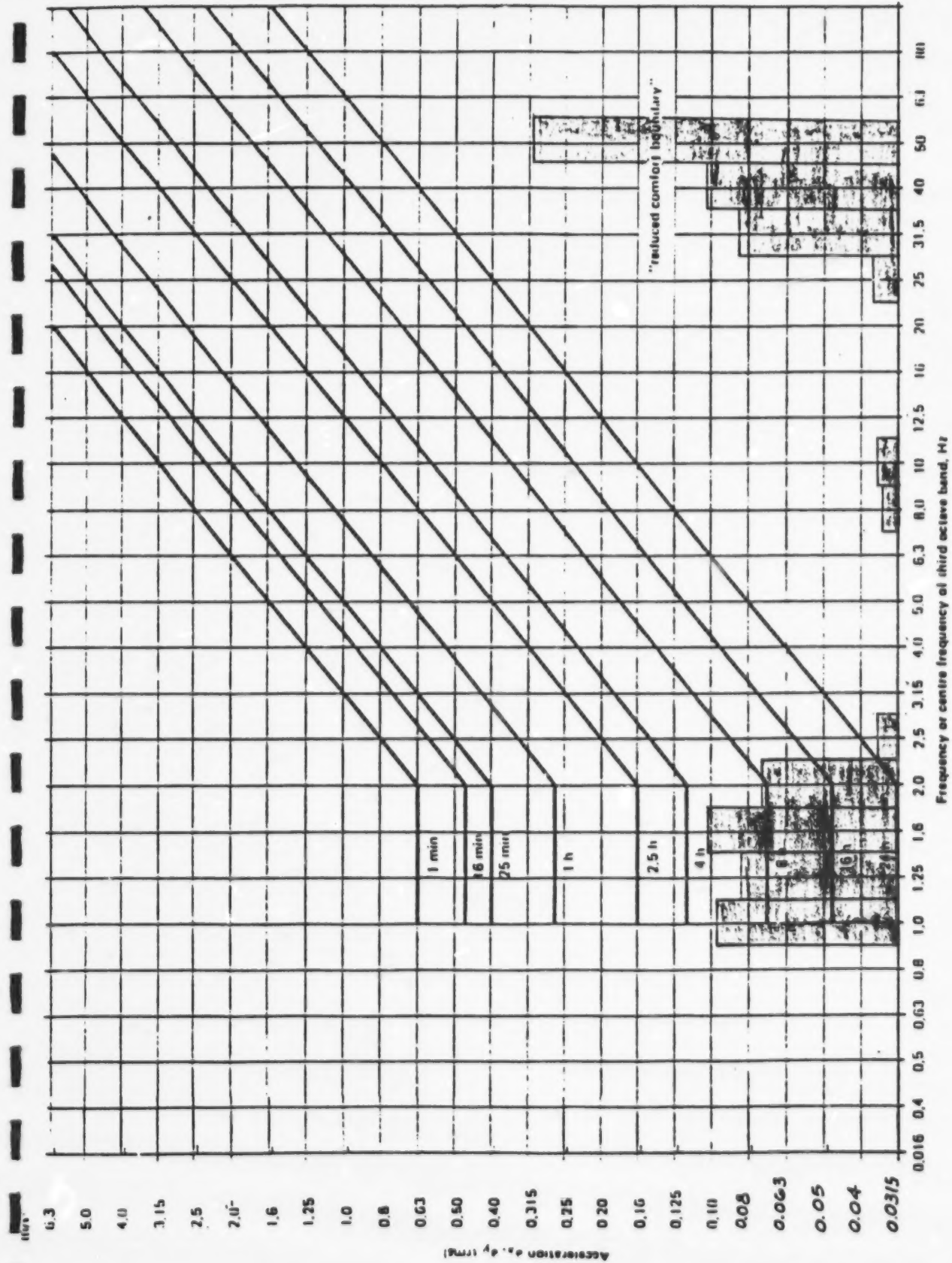


FIGURE 5 - ISO RIDE QUALITY BC-12 (UNMODIFIED RDC) ON TANGENTIAL TRACK

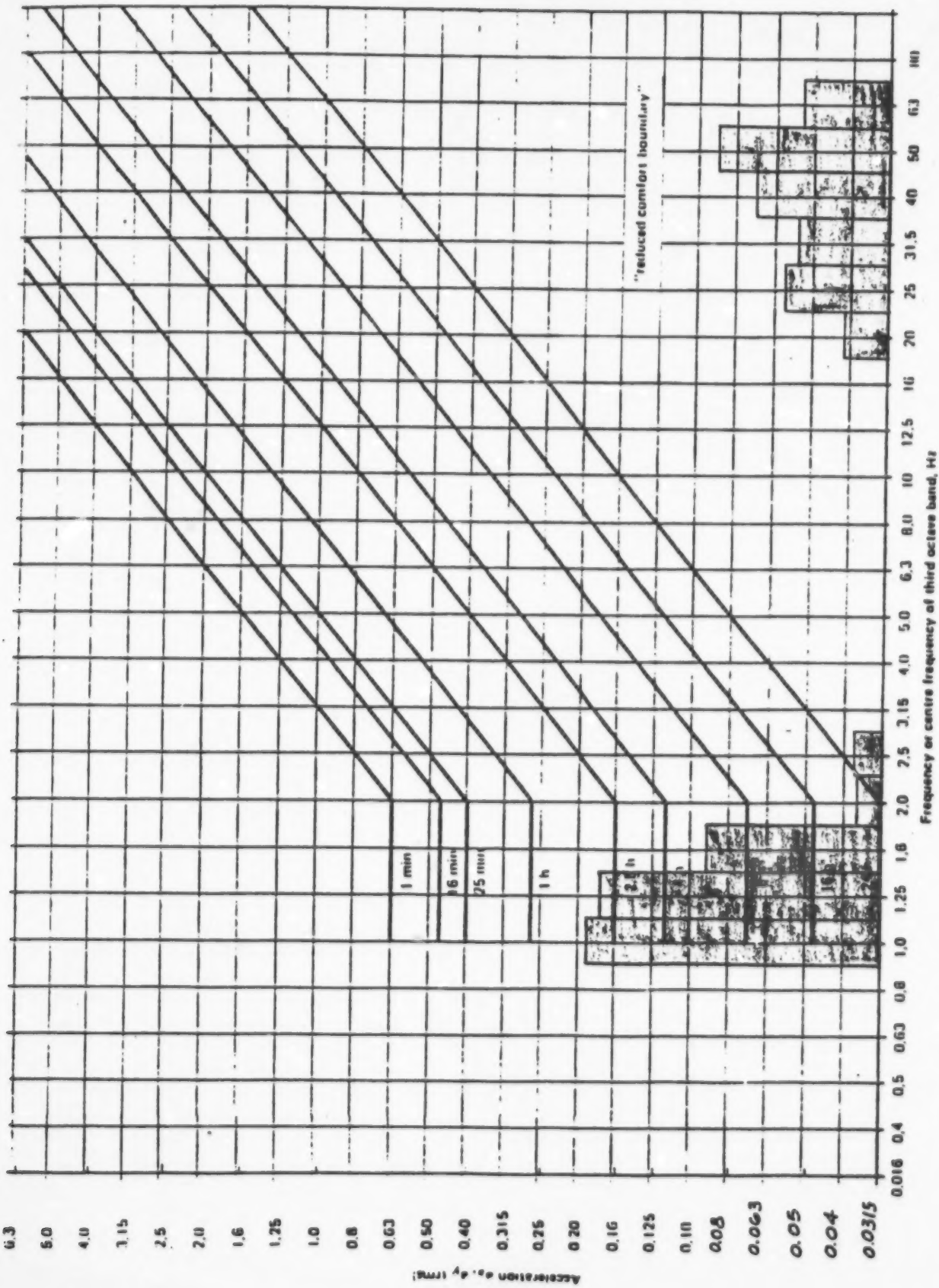


FIGURE 6 - ISO RIDE QUALITY BC-33 (MODIFIED RDC) ON CURVED TRACK

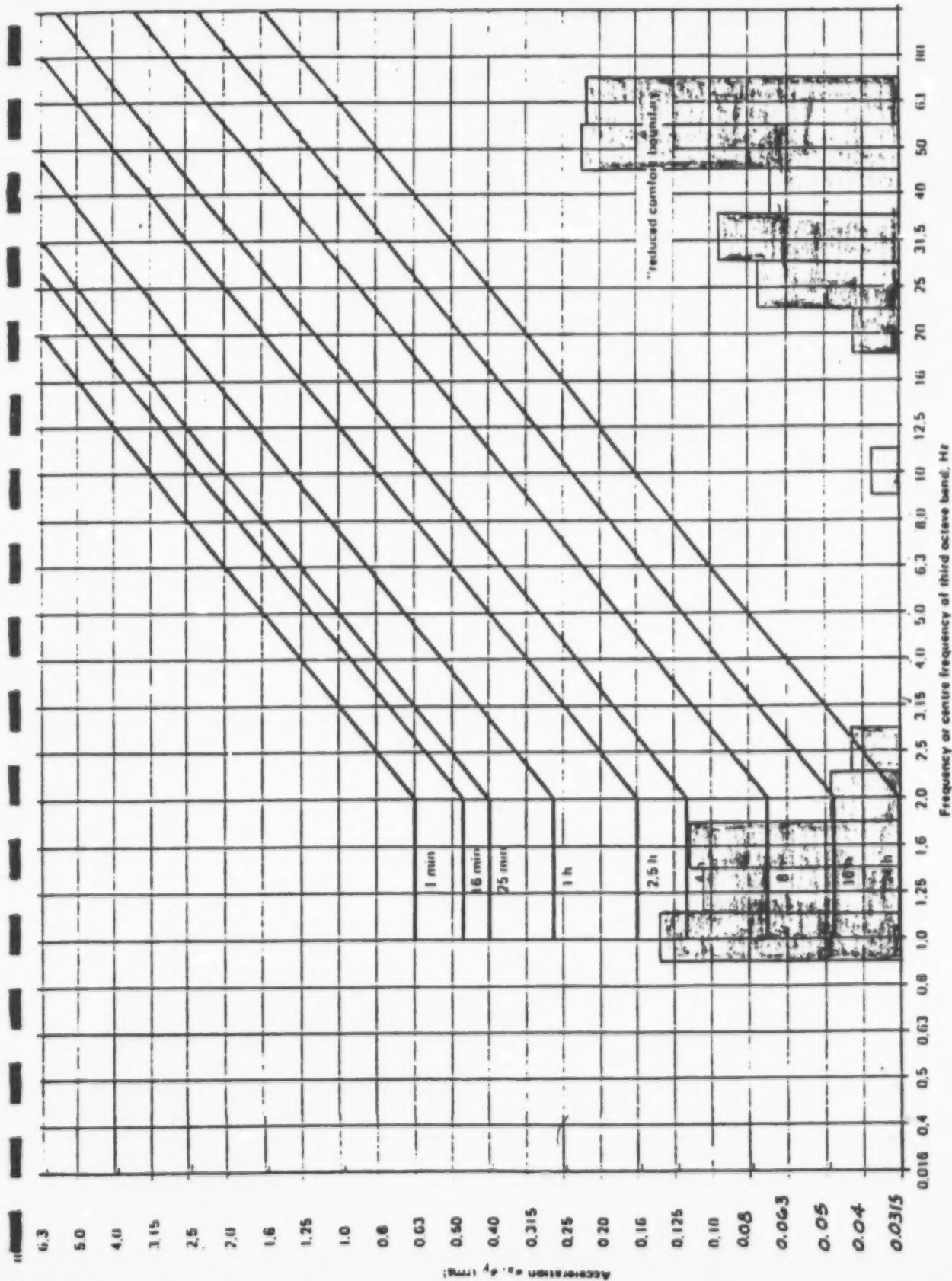


FIGURE 7 - ISO RIDE QUALITY BC-12 (UNMODIFIED RDC) ON CURVED TRACK

APPENDIX G - BC Rail Through Freight Train Report - 1981, 1982 and 1983

Source: British Columbia Railway Through Freight Train Report

Analysis by: Exception, i.e. documented for delays due to unscheduled maintenance to rolling stock.

Passenger Train Schedule

No. 1 Daily (North)	Leave North Vancouver	07:30
	Arrive Lillooet	12:35
No. 2 Daily (South)	Leave Lillooet	15:25
	Arrive North Vancouver	20:30

Service

- 1) North Vancouver to Lillooet and return, daily.
- 2) North Vancouver to Prince George Wednesday, Friday and Sunday.
- 3) Prince George to North Vancouver Monday, Tuesday and Saturday.

The table is based upon frequency of trips. Some trips are between North Vancouver and Prince George, while other trips are from North Vancouver to Lillooet and return.

Please note that when BC-33 is used on the head-end, it remains on the consist all the way to Prince George, unless there is unscheduled maintenance.

The purpose of the tables is not to show the duration of the delay, but to determine the car number and the reason for the delay.

Delays of 10 minutes or less have been noted on the attached tables, but have not been included in the analysis.

ON TIME PERFORMANCE - 1983

NO. 1

date	units	problem	delay
83/01/02	BC33-31-10-11	Servicing at Lill.	10 min
		Servicing at W.L.	19 min
83/01/05		Servicing at Lill.	05 min
83/01/07	BC33-10-11-31	BC33-repeated shutdowns	05 min
83/01/09		Servicing at Lill.	05 min
		BC33-add trans. oil	
		BC10-#1 motor low oil, died	25 min
		BC10-restart #1 at Ques.	15 min
83/01/12		Servicing at W.L.	07 min
83/01/13	BC31-11	N.V.-all motors not clutch.	20 min
		BC31-restart #2 twice	22 min
83/01/14		BC31-#2 motor shutdown	25 min
83/01/18		BC10-repair trainline	15 min
83/01/23		BC12-brake problems	15 min
83/01/28		Servicing at Lill.	05 min
83/01/30	BC33-10-12-31	BC33-unplug toilet	15 min
		Servicing at W.L.	10 min
83/02/02		Servicing at Lill.	05 min
83/02/03		BC31-air press. problem	10 min
83/02/06		BC10-air problem	15 min
83/02/09		BC11-restart motor	04 min
83/02/11		Servicing at Lill.	07 min
83/02/13		Servicing at Lill.	05 min
83/02/16	BC33-10-11-31-12	BC31-b/o jumper cable	10 min
		Set out BC12 at Sq.	10 min
83/02/18	BC33-12-11-31	Servicing at Lill.	15 min
83/02/20		BC33-toilet problem	08 min
83/03/02		BC11-air problems	20 min
83/03/04		Servicing at Lill.	05 min
83/03/05	BC31-12	BC31-b/o comp. piping	77 min
83/03/06		Pick up BC10	10 min
83/03/13		Servicing at Lill.	05 min
83/03/23		Servicing at Lill.	05 min
		BC31-mechanical problems	70 min
83/03/27		Servicing at Lill.	05 min
83/03/30	BC31-12-11-10	Collision-hit tree	10 min
		Servicing at Lill.	10 min
83/03/29	BC10-11	B/o jumper cable	10 min
83/04/01		BC31-add water	20 min
83/04/03	BC10-33-11-12-31	Servicing at W.L.	15 min
83/04/13		BC33-low oil #2 motor & washroom problem	20 min
		BC33-motor & water pump b/o	20 min
83/04/20		BC33-air trouble	115 min
83/04/22		BC12-b/o air hose	15 min
83/05/18		BC31-engine trouble	10 min
83/05/21	/	BC31-restart both motors	10 min
83/06/05		BC31-motor trouble	15 min
83/06/10		BC11-engine trouble	10 min
83/07/24		BC33-brake problem	20 min
		BC10-restart engine	07 min
83/07/28	BC31-12	3 motors died	06 min
83/07/29		BC10-restart both motors	06 min
83/07/21		BC33-reset trans. buttons	12 min
83/08/01		Restart motors on BC31-10	10 min
83/08/03	BC33-10-12-31	BC33-broken air line	27 min
83/08/05	BC31-11-10-33-12	BC33-mech. trouble: set out	35 min
		BC31-trouble starting	69 min

83/08/07		Start motors BC31-10	05 min
83/08/10		Start motors BC31	12 min
83/08/12		Start motors BC31-11	20 min
83/08/21	BC33-11-10-12-31	BC10-both motors died	
		BC11-#1 motor died	10 min
83/08/28		BC11-brake problem	20 min
83/08/31	BC33-31-12-11	Brakes would not release	20 min
83/09/18		BC31-add water	05 min
83/10/03	BC10	BC10-#1 motor not clutch.	27 min
83/10/07		BC12-restart motor	07 min
83/10/12	BC33-11-10-31	BC10-air leak on #1 motor	15 min
83/10/26		BC33-b/o oil press. switch	20 min
83/11/02		BC33-air brake problems	135 min
83/12/21		BC33-restart motor	06 min
83/12/22		Restart motors BC20	06 min
83/12/24		BC12-work on heater	05 min
83/12/25		BC31-restart motors	35 min
83/12/28		BC30-work on equalizer	10 min
83/12/30	BC20-12-10	M.U. jumper problems	23 min

ON TIME PERFORMANCE - 1983

NO. 2

date	units	problem	delay
83/01/03	BC33-31-10-11	BC31-compressor control b/o	15 min
83/01/06	BC33-11-10-31	BC33-trans. button tripping	10 min
83/01/08		BC33-restart motor	14 min
83/01/10	BC33-10-12-11	Servicing at W.L.	10 min
		Servicing at Lill.	10 min
83/01/11	BC12-11	BC12-restart motor	20 min
83/01/13		BC33-#2 motor died	
		BC12-both motors died	10 min
83/01/15		BC33-comp. breaker tripping	40 min
		BC11-engine failure	115 min
83/01/16		BC31-engine failed	110 min
83/01/17		BC11-air problem	23 min
83/01/27	BC33-12-10-31	BC10- replace #3 brng plate	35 min
83/02/11	BC33-11	Servicing at Lill.	10 min
		BC33-#1 motor died	
83/02/16		BC11-#1 trans. reset	15 min
83/02/22		Pick up BC12 at Sq.	15 min
83/02/24		Pick up BC31 at Sq.	10 min
83/02/28		Engine trouble BC31-12	20 min
83/03/05	BC31-12-33	Pick up BC33 at Sq.	25 min
		BC31-#1 comp. line failed	97 min
		BC10-#2 motor would not start	40 min
		BC31-m.r. line blanked off	15 min
83/03/07	BC12-31-11-10-	BC33-broken air line #2 motor	49 min
83/03/17		M.U. & service at Lill.	10 min
83/03/21		BC33-#2 trans tripping	10 min
83/03/26	BC33-10-12-31	BC31-10 - add water	10 min
83/03/31	BC31-12-11-10	Brake problem-valve open BC10	10 min
83/04/02		Servicing at Lill.	10 min
83/04/04		BC33-Brake failure	50 min
83/04/11		BC33-restart #2 motor	15 min
83/04/14		BC33-restart #2 motor	15 min
83/05/28	BC31-12-11-10	Pick up BC31-12	22 min
		BC31-restart motor	

83/06/03		BC10-restart both motors	30 min
83/06/15		BC11-engine failed	30 min
83/06/27	BC31-11-12-10	Held acct. fire at south yd Lill	35 min
83/07/04		BC33-failed motor	78 min
83/07/11		BC33-add water	13 min
83/07/18		BC33-restart motors	18 min
83/07/21		BC10-restart #2 motor	08 min
83/07/25	BC33-10	B/O mu cable	10 min
83/07/30		BC12-a.c. problems	15 min
83/08/01		BC33-12 motor problems	10 min
83/08/03		BC12-restart engine	10 min
83/08/12	BC10-31	BC31-both motors died, BC10 both trans. tripping	5'30 min
83/08/15	BC33-31-12-11	2 engines shutdown - unknown	10 min
83/08/20	BC33-31-12-10-11	BC33-apu shutdown at W.L.	15 min
		BC33-brake trouble at Lill.	15 min
83/08/22		BC33-11-add oil	10 min
83/08/29		BC33-cleaning at Lill.	10 min
83/09/05		BC33-restart motor	10 min
83/09/10		BC33-failed engine	52 min
83/09/11		BC33-mechanical problems	32 min
83/09/15	BC31-11-10	BC33-restart #2 motor	10 min
83/09/18		BC11-brakes	10 min
83/10/15	BC33-10 12-31	BC33-broken air line	40 min
83/11/21		BC31-both engines quit	280 min
83/11/26		BC33-unlock washroom door	10 min
83/12/03		BC33-restart engines	45 min
83/12/15		BC33-repair heater	37 min

ON TIME PERFORMANCE- 1982

NO. 1

date	units	problem	delay
82/01/02		BC31-10-engine trouble	135 min
82/01/21		BC31-restart motor	29 min
82/01/24		BC10-motors shutting down	33 min
82/01/25		BC10-#1 motor restart	20 min
82/01/29		BC30-pan off	10 min
82/01/30		BC30-low power	20 min
82/02/02		BC12-restart #1 motor	05 min
82/02/06		BC10-not clutching	08 min
82/02/13		B/O compressor	35 min
82/02/15		BC12-broken air hose	40 min
82/02/20		Low power	16 min
82/03/12		BC30-mech. repairs	25 min
82/03/24		BC30-mech. repairs	05 min
82/04/02		BC10-cooling fan	40 min
82/04/04		BC10-restart motor	20 min
82/04/10		BC31-12-motors shutting down	28 min
82/04/24		BC31-compressor trouble	35 min
82/05/02		BC11-mech. repairs	16 min
82/05/23		BC31-engine problems	35 min
82/06/05		BC31-10-motor trouble	70 min
82/06/12		BC10-compressor	10 min
82/06/17		BC30-no a.c. power	20 min
82/06/18		Set out BC10	16 min
82/06/23		BC31-shutting down	19 min
82/07/01		BC11-repairs	10 min
82/07/04		BC11-#1 motor shut down	05 min
82/07/05		BC11-restart motor	05 min
82/07/13		BC30-on fire	85 min
82/07/29		BC11-no a.c. power	05 min
82/08/09		BC31-no a.c. power	10 min
82/08/12		BC31-repair ditch lights	05 min
82/08/14		BC31/11- b/o jumper cable	15 min
82/08/21		BC31-would not start	100 min
82/08/28		BC12-no a.c. power	50 min
82/08/30		BC31-compressor	15 min
82/09/10		BC10-restart motor	55 min
82/09/13		BC31-restart motor	15 min
82/09/19		BC31-restart #2 motor	30 min
82/09/21		BC10-mech. repairs	35 min
82/09/27		BC31-restart motor	16 min
82/10/06		BC-motor failure	65 min
82/10/31		BC31-lights	30 min
82/11/03		BC30-repair lights	05 min
82/11/10		BC33-restart motors	60 min
82/11/12		BC31/11 - b/o jumper cable	15 min
82/11/17		BC33-motors & toilet	32 min
82/11/19		BC33-fuel leak	15 min
82/12/06		BC12-restart #2 motor	15 min
82/12/12		BC33-brakes	05 min
82/12/18		BC31-not clutching	45 min
82/12/24		BC31/11-restart motors	13 min
82/12/25		BC31-restart motor	05 min
82/12/29		BC31-brakes	15 min
82/12/30		BC12-restart motors	75 min

ON TIME PERFORMANCE - 1982

NO. 2

date	units	problem	delay
82/01/02		Restart motors on BC12-11	50 min
82/01/04		BC30-air compressor	10 min
82/01/06		Low power	08 min
82/01/12		BC31-10-jumper cable	17 min
82/01/16		BC31-restart motor	20 min
82/01/17		BC30-10-restart motors	158 min
82/01/19		BC31-12-engine trouble	20 min
82/02/07		BC30-#1 motor not clutching	30 min
82/02/14		BC30-failed	Canc.
82/02/23		BC12-restart motor	15 min
82/02/26		BC10-repairs	10 min
82/02/28		BC30-bearing cover	20 min
82/03/02		BC30-repairs	20 min
82/03/05		BC31-restart	10 min
82/03/18		Low power	15 min
82/03/19		BC12-air problems	35 min
82/04/01		BC31-voltage regulator	30 min
82/04/03		BC10-repairs	25 min
82/04/12			165 min
82/04/26		BC31-air trouble	20 min
82/06/04		BC30-repair fridge	10 min
82/06/18		BC11-no a.c.	25 min
82/06/30		BC30-compressor	50 min
82/07/03		BC30-11-engine trouble	36 min
82/07/18		BC12-restart motor	23 min
82/07/27		BC31-no a.c.	05 min
82/07/30		BC11-no a.c.	45 min
82/08/23		BC10-restart motor	10 min
82/08/24		BC10-no a.c.	10 min
82/09/02		BC10-restart #1	34 min
82/09/10		BC31-engine failure	80 min
82/09/14		BC10-restart #2	30 min
82/09/17		BC10-restart #1	10 min
82/10/08		BC10-repairs	05 min
82/10/24		BC31-air problems	10 min
82/11/17		BC10-drive shaft	90 min
82/11/22		BC11-add water	10 min
82/12/02		BC11-repair wiring	10 min
82/12/18		BC10-air hose	10 min
82/12/20		BC10-actuating line repair	08 min
82/12/23		BC11-roller bearing	45 min
82/12/27		BC12-#2 transmission button	15 min

ON TIME PERFORMANCE - 1981

NO.1

date	units	problem	delay
81/03/23	BC33-11-12	Repairs to budds	05 min
81/04/13	BC11-33	B/O jumper cable	05 min
81/05/04	BC33-12-11	Servicing at Lill.	10 min
81/05/09		BC33-#1 motor shutdown	05 min
81/05/10		BC31-10-add water & adjust seat	35 min
81/05/20	BC31-11	B/O jumper cable	05 min
81/06/13	BC31-10	Servicing at Lill.	30 min
81/06/26		BC31-add oil	48 min
81/07/04		BC30-no a.c.	15 min
81/07/18	BC30-11	Servicing at Lill.	10 min
81/07/27		BC11-repairs	15 min
81/08/01		BC12-add service water	08 min
		BC11-no a.c.	10 min
81/08/10		BC30-low oil	15 min
81/08/13		BC30-repairs	87 min
81/08/24	BC30-10-12	Brakes not releasing	35 min
81/08/31		BC12-low oil	10 min
81/09/12		BC30-engine repairs	70 min
81/09/14		BC30-no a.c.	05 min
81/10/03	BC30-12	BC12-engine trouble	58 min
81/10/05	BC30-12-10-31	Servicing at Lill.	10 min
81/10/13		BC12-water leak	10 min
81/10/17		BC10-jumper cable	16 min
81/10/21	BC30-10	B/O jumper cable	16 min
81/10/29		BC30-#1 motor died	15 min
81/11/04		BC10-failed	65 min
81/11/23		BC31-not clutching	11 min
81/11/25		BC10-restart motor	10 min
81/12/10		BC30-air compressor	15 min
81/12/16		BC31-repair heater	05 min
81/12/18		BC10-replace occ. light	05 min
81/12/19		BC10-restart #1 motor	15 min
81/12/24		BC31-repair heater	10 min
81/12/26	BC30-31-12-11-10	Low power	15 min
81/12/30		BC31-repair headlight	25 min
		BC31-shutting down	30 min

ON TIME PERFORMANCE - 1981

NO. 2

date	units	problem	delay
81/01/10		BC12-check lights	05 min
81/03/20		BC11-motor shutdown	10 min
81/04/05		BC11-repair heater	15 min
81/04/26		BC12-add water	10 min
81/05/10		BC11-restart motor	10 min
81/06/30	BC30-12	Engine trouble	10 min
81/08/02		BC30-11-b/o jumper cable	60 min
		BC30-trans. fluid	05 min
81/08/07		BC11-10-overcharging	25 min
81/08/11		BC10-30-no a.c.	25 min
81/08/21		BC11-overcharging	15 min
81/08/13	BC30-10	Servicing at W.L.	15 min
81/09/20		BC30-change air hose	25 min
81/10/04		BC30-restart motor	09 min
81/10/05		BC30-#1 motor not clutching	25 min
81/10/06		BC10-air hose	10 min
81/11/03		Pick up BC10	16 min
81/11/04		Pick up BC11, set out BC10	80 min
81/11/20		BC31-no power	10 min
81/11/23		Pick up BC30	10 min
81/12/06		BC11-b/o jumper cable	10 min
81/12/13		BC31-repairs	60 min
81/12/18		BC11-water leak	05 min
81/12/20	BC31-10-12-11	Servicing at Lill.	10 min
81/12/22	BC30-31-11	Servicing at W.L.	10 min
81/12/29		BC12-motor problems	30 min

APPENDIX H - Maintenance Costs - Budd Cars

MAINTENANCE COSTS - BUDD CARS

BC-33 (Before Modification or Upgrading) versus BC-31

July 1980 to June 1981

	July 1980	Aug. 1980	Sept. 1980	Oct. 1980	Nov. 1980	Dec. 1980	Jan. 1981	Feb. 1981	March 1981	April 1981	May 1981	June 1981	Total 12 Months	Average per Month
	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$		
BC-31														
Labour	471	216	2,148	645	795	714	1,158	183	630	184	1,032	387	8,563	713
Material	189		689	598	30	251	156	30	225	220	247	168	2,803	234
Outside Service	114		240	50		197							601	50
TOTAL	774	216	3,077	1,293	825	1,162	1,314	213	855	404	1,279	555	11,967	997

BC-33 vs
BC-31

BC-33														
Labour	649	127	306	687	650	748	380	721	905	596	1,138	3,316	10,223	852
Material	307		271	671	315	75	1,016	426	580	836	333	143	4,973	414
Outside Service	223									135			358	30
Total	1,179	127	577	1,358	965	823	1,396	1,147	1,485	1,567	1,471	3,459	15,554	1,296 +30%

MAINTENANCE COSTS - BUDD CARS

BC-31 (BC-33 Out of Service for Modification)

July 1981 to October 1982

	July 1981	Aug. 1981	Sept. 1981	Oct. 1981	Nov. 1981	Dec. 1981	Jan. 1982	Feb. 1982	March 1982	April 1982	May 1982	June 1982	July 1982	Aug. 1982	Sept. 1982	Oct. 1982
BC-31	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$	\$
Labour	267	578	795	639	851	1,850	473	1,355	329	3,337	729	2,708	1,255	1,782	1,560	875
Material	105	569	961	339	15	710	248	1,319	489	2,129	864	5,798	2,671	2,359	700	1,085
Outside Services	1,438					128					41			1,688	266	
TOTAL	1,810	1,147	1,756	978	866	2,688	721	2,674	818	5,466	1,634	8,506	3,926	5,829	2,526	1,960

Average/Month

Total - 16 Months

Labour	19,383	1,615
Material	20,361	1,697
Outside Services	3,561	297
TOTAL	43,305	3,609

MAINTENANCE COSTS - BUDD CARS

BC-33 (After Modification) versus BC-31

November 1982 to October 1983

	Nov. 1982	Dec. 1982	Jan. 1983	Feb. 1983	March 1983	April 1983	May 1983	June 1983	July 1983	Aug. 1983	Sept. 1983	Oct. 1983	Total 12 Months	Average per Month
BC-31														
Labour	4,528	2,162	2,552	1,160	1,947	5,077	1,246	2,806	3,421	6,512	2,143	2,081	35,635	2,970
Material	1,175	187	966	464	462	1,180	627	949	703	204	2,716	2,242	11,875	989
Outside Services			229		91					257		20	597	50
TOTAL	5,703	2,349	3,747	1,624	2,500	6,257	1,873	3,755	4,124	6,973	4,859	4,343	48,107	4,009

BC-33 vs
BC-31

BC-33														
Labour	5,629	666	2,055	8,545	2,039	5,718	2,008	569	5,511		5,942	2,625	41,307	3,442
Material	2,079	895	1,726	1,524	821	1,059	618	778	3,902		3,620	5,847	22,869	1,906
Outside Services	219	228	55	48	398	1,012	1,437	248	1,312		(2,348)	4,298	6,907	576
TOTAL	7,927	1,789	3,836	10,117	3,258	7,789	4,063	1,595	10,725	-	7,214	12,770	71,083	5,924 +48%

APPENDIX I - Fuel Consumption Survey

Fuel Oil Mileage Factor for RDC Cars

Budd car fuel consumption has been analyzed over an accumulated mileage of 24,880. Although by no means an exhaustive study, the results are seen as a reasonable indication of actual consumption.

Consumption includes idle time and is based on trip mileage, as provided by Dispatchers rather than actual miles. Trip mileage is +8%.

Average Consumption

$\frac{8,632 \text{ gallons}}{24,880 \text{ miles}} = 0.35 \text{ GPM} = (2.88 \text{ mpg})$

Average less BC-33

$\frac{6,318 \text{ gallons}}{18,460 \text{ miles}} = 0.34 \text{ GPM} = (2.92 \text{ mpg})$

Average BC-33 (only)

$\frac{2,314 \text{ gallons}}{6,420 \text{ miles}} = 0.36 \text{ GPM} = (2.77 \text{ mpg})$

Current factor used for estimating fuel consumption is:

RDC-1 = 0.42
RDC-3 = 0.41 (Average 0.415)

Recommended adjusted factor:

BC-33 only = 0.36
BC-10 to BC-31 = 0.34 (Average 0.35)

Assuming that this fairly selective test is in fact generally representative of actual conditions, the following summary applies:

Gallon per mile consumption is reduced by 0.068.
A 16% reduced consumption is indicated.
A saving of 1.400 gallon was realized.

Source: C.V. Pedersen, Supervisor Motive Power, Mechanical Dept.

AMOUNT OF FUEL ADDED IN GALLONS AND LOCATION

Legend

NV = North Vancouver WL = Williams Lake
L = Lillooet PG = Prince George

<u>Date - 1983</u>	<u>BC-33</u>	<u>BC-31</u>	<u>BC-30</u>	<u>BC-10</u>	<u>BC-11</u>	<u>BC-12</u>
October 1	127 NV WL		O/S SQ		45 L 58 NV	68 NV WL
October 2	100 WL 88 PG	60 L 50 NV		60 L 54 NV	45 NV	90 WL 75 PG
October 3	63 WL 120 NV	60 L		50 NV 60 L 60 L		56 WL 63 NV
October 4	33 NV	40 NV		44 NV		32 NV
October 5	115 WL 64 PG	63 L 51 NV		57 L 33 NV		80 WL 79 PG
October 6	69 WL 114 NV	60 L 63 NV		60 L 55 NV		60 WL 103 NV
October 7	129 WL 83 PG	60 L 41 NV		60 L 46 NV		69 WL 46 PG
October 8	98 NV 75 WL	72 NV 40 L		61 NV 43 L	111 NV	78 NV 60 WL
October 9	55 PG 109 WL	44 L 46 NV		44 L 49 NV	40 PG 100 WL	
October 10	46 WL 111 NV	57 L 50 NV		53 L 48 NV	62 WL 82 NV	
October 11		56 L 41 NV		60 L 46 NV		
October 12	136 WL 60 PG	60 L 46 NV		60 L 46 NV	116 WL 55 PG	
October 13	43 WL 74 NV	60 L 50 NV		54 L 54 NV	56 WL 88 NV	
October 14	128 WL 50 PG			98 WL 54 PG	60 L 52 NV	107 NV
October 15	59 WL 102 NV	48 L 84 NV		57 WL 85 NV	56 L 45 NV	32 L 40 NV
TOTALS	2,251	1,302	-	1,550	1,071	1,138